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COCOANUT GROVE NEAR THE MARINE LABORATORY AT TORTUGAS, FLORIDA.

CARNEGIE INSTITUTION

OF

WASHINGTON

YEAR BOOK

No. 6

1907

PUBLISHED BY THE INSTITUTION
WASHINGTON, U. S. A.
JANUARY, 1908

PRESS OF JUDD & DETWEILER, INC.
WASHINGTON, D. C.

336.5

OFFICERS FOR THE YEAR 1908

President of the Institution

ROBERT S. WOODWARD

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ELIHU ROOT, *Vice-Chairman*
CLEVELAND H. DODGE, *Secretary*

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JOHN L. CADWALADER
CLEVELAND H. DODGE
WILLIAM N. FREW
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DANIEL C. GILMAN
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E. A. HITCHCOCK
CHAS. L. HUTCHINSON
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WILLIAM H. WELCH
ANDREW D. WHITE
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Executive Committee

CARROLL D. WRIGHT, *Chairman*

*JOHN S. BILLINGS
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*ROBERT S. WOODWARD
CARROLL D. WRIGHT

Finance Committee

D. O. MILLS
HENRY L. HIGGINSON
SETH LOW

* Ex-officio member.

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ARTICLES OF INCORPORATION.

The Carnegie Institution was originally organized under the law governing the organization of corporations in the District of Columbia. Owing to certain limitations in the law, the Trustees deemed it desirable to obtain articles of incorporation from the Congress. Accordingly, articles of incorporation were prepared, submitted to the Congress, amended by the Congress, and enacted into statute by the Congress and the signature of the President.

Organization under the new articles of incorporation was effected on May 18, 1904. Resolutions were passed electing the same Executive Committee and officers as those of the Carnegie Institution organized in 1902 and continuing all instructions and authorizations given to the Executive Committee by the old organization.

PUBLIC No. 260.—An Act To incorporate the Carnegie Institution of Washington.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the persons following, being persons who are now trustees of the Carnegie Institution, namely, Alexander Agassiz, John S. Billings, John L. Cadwalader, Cleveland H. Dodge, William N. Frew, Lyman J. Gage, Daniel C. Gilman, John Hay, Henry L. Higginson, William Wirt Howe, Charles L. Hutchinson, Samuel P. Langley, William Lindsay, Seth Low, Wayne MacVeagh, Darius O. Mills, S. Weir Mitchell, William W. Morrow, Ethan A. Hitchcock, Elihu Root, John C. Spooner, Andrew D. White, Charles D. Walcott, Carroll D. Wright, their associates and successors, duly chosen, are hereby incorporated and declared to be a body corporate by the name of the Carnegie Institution of Washington and by that name shall be known and have perpetual succession, with the powers, limitations, and restrictions herein contained.

SEC. 2. That the objects of the corporation shall be to encourage, in the broadest and most liberal manner, investigation, research, and discovery, and the application of knowledge to the improvement of mankind; and in particular—

(a) To conduct, endow, and assist investigation in any department of science, literature, or art, and to this end to cooperate with governments, universities, colleges, technical schools, learned societies, and individuals.

(b) To appoint committees of experts to direct special lines of research.

(c) To publish and distribute documents.

(d) To conduct lectures, hold meetings and acquire and maintain a library.

(e) To purchase such property, real or personal, and construct such building or buildings as may be necessary to carry on the work of the corporation.

(f) In general, to do and perform all things necessary to promote the objects of the institution, with full power, however, to the trustees hereinafter appointed and their successors from time to time to modify the conditions and regulations under which the work shall be carried on, so as to secure the application of the funds in the manner best adapted to the conditions of the time, provided that the objects of the corporation shall at all times be among the foregoing or kindred thereto.

SEC. 3. That the direction and management of the affairs of the corporation and the control and disposal of its property and funds shall be vested in a board of trustees, twenty-two in number, to be composed of the following individuals: Alexander Agassiz, John S. Billings, John L. Cadwalader, Cleveland H. Dodge, William N. Frew, Lyman J. Gage, Daniel C. Gilman, John Hay, Henry L. Higginson, William Wirt Howe, Charles L. Hutchinson, Samuel P. Langley, William Lindsay, Seth Low, Wayne MacVeagh, Darius O. Mills, S. Weir Mitchell, William W. Morrow, Ethan A. Hitchcock, Elihu Root, John C. Spooner, Andrew D. White, Charles D. Walcott, Carroll D. Wright, who shall constitute the first board of trustees. The board of trustees shall have power from time to time to increase its membership to not more than twenty-seven members. Vacancies occasioned by death, resignation, or otherwise shall be filled by the remaining trustees in such manner as the by-laws shall prescribe; and the persons so elected shall thereupon become trustees and also members of the said corporation. The principal place of business of the said corporation shall be the city of Washington, in the District of Columbia.

SEC. 4. That such board of trustees shall be entitled to take, hold and administer the securities, funds, and property so transferred by said Andrew Carnegie to the trustees of the Carnegie Institution and such other funds or property as may at any time be given, devised, or bequeathed to them, or to such corporation, for the purposes of the trust; and with full power from time to time to adopt a common seal, to appoint such officers, members of the board of trustees or otherwise, and such employees as may be deemed necessary in carrying on the business of the corporation, at such salaries or with such remuneration as they may deem proper; and with full power to adopt by-laws from time to time and such rules or regulations as may be necessary to secure the safe and convenient transaction of the business of the corporation; and with full power and discretion to deal with and expend the income of the corporation in such manner as in their judgment will best promote the objects herein set forth and in general to have and use all powers and authority necessary to promote such objects and carry out the purposes of the donor. The said trustees shall have further power from time to time

to hold as investments the securities hereinabove referred to so transferred by Andrew Carnegie, and any property which has been or may be transferred to them or such corporation by Andrew Carnegie or by any other person, persons, or corporation, and to invest any sums or amounts from time to time in such securities and in such form and manner as are permitted to trustees or to charitable or literary corporations for investment, according to the laws of the States of New York, Pennsylvania, or Massachusetts, or in such securities as are authorized for investment by the said deed of trust so executed by Andrew Carnegie, or by any deed of gift or last will and testament to be hereafter made or executed.

SEC. 5. That the said corporation may take and hold any additional donations, grants, devises, or bequests which may be made in further support of the purposes of the said corporation, and may include in the expenses thereof the personal expenses which the trustees may incur in attending meetings or otherwise in carrying out the business of the trust, but the services of the trustees as such shall be gratuitous.

SEC. 6. That as soon as may be possible after the passage of this Act a meeting of the trustees hereinbefore named shall be called by Daniel C. Gilman, John S. Billings, Charles D. Walcott, S. Weir Mitchell, John Hay, Elihu Root, and Carroll D. Wright, or any four of them, at the city of Washington, in the District of Columbia, by notice served in person or by mail addressed to each trustee at his place of residence; and the said trustees, or a majority thereof, being assembled, shall organize and proceed to adopt by-laws, to elect officers and appoint committees, and generally to organize the said corporation; and said trustees herein named, on behalf of the corporation hereby incorporated, shall thereupon receive, take over, and enter into possession, custody, and management of all property, real or personal, of the corporation heretofore known as the Carnegie Institution, incorporated, as hereinbefore set forth under "An Act to establish a Code of Law for the District of Columbia, January fourth, nineteen hundred and two," and to all its rights, contracts, claims, and property of any kind or nature; and the several officers of such corporation, or any other person having charge of any of the securities, funds, real or personal, books or property thereof, shall, on demand, deliver the same to the said trustees appointed by this Act or to the persons appointed by them to receive the same; and the trustees of the existing corporation and the trustees herein named shall and may take such other steps as shall be necessary to carry out the purposes of this Act.

SEC. 7. That the rights of the creditors of the said existing corporation known as the Carnegie Institution shall not in any manner be impaired by the passage of this Act, or the transfer of the property hereinbefore mentioned, nor shall any liability or obligation for the payment of any sums due or to become due, or any claim or demand, in any manner or for any cause

existing against the said existing corporation, be released or impaired; but such corporation hereby incorporated is declared to succeed to the obligations and liabilities and to be held liable to pay and discharge all of the debts, liabilities, and contracts of the said corporation so existing to the same effect as if such new corporation had itself incurred the obligation or liability to pay such debt or damages, and no such action or proceeding before any court or tribunal shall be deemed to have abated or been discontinued by reason of the passage of this Act.

SEC. 8. That Congress may from time to time alter, repeal, or modify this Act of incorporation, but no contract or individual right made or acquired shall thereby be divested or impaired.

SEC. 9. That this Act shall take effect immediately.

Approved, April 28, 1904.

BY-LAWS OF THE INSTITUTION.

Adopted December 13, 1904.

ARTICLE I.

THE TRUSTEES.

1. The Board of Trustees shall consist of twenty-four members, with power to increase its membership to not more than twenty-seven members. The Trustees shall hold office continuously and not for a stated term.

2. In case any Trustee shall fail to attend three successive annual meetings of the Board he shall thereupon cease to be a Trustee.

3. No Trustee shall receive any compensation for his services as such.

4. All vacancies in the Board of Trustees shall be filled by the Trustees by ballot. No person shall be elected, however, who shall not have been nominated at a preceding annual or special meeting, except by the unanimous consent of the members present at a meeting.

ARTICLE II.

MEETINGS.

1. The annual meeting of the Board of Trustees shall be held in the City of Washington, in the District of Columbia, on the second Tuesday of December in each year.

2. Special meetings of the Board may be called by the Executive Committee by notice served personally upon, or mailed to the usual address of, each Trustee twenty days prior to the meeting.

3. Special meetings shall, moreover, be called in the same manner by the Chairman upon the written request of seven members of the Board.

ARTICLE III.

OFFICERS OF THE BOARD.

1. The officers of the Board shall be a Chairman of the Board, a Vice-Chairman, and a Secretary, who shall be elected by the Trustees, from the members of the Board, by ballot to serve for a term of three years. All vacancies shall be filled by the Board for the unexpired term; provided, however, that the Executive Committee shall have power to fill a vacancy in the office of Secretary to serve until the next meeting of the Board of Trustees.

2. The Chairman shall preside at all meetings and shall have the usual powers of a presiding officer.

3. The Vice-Chairman, in the absence or disability of the Chairman, shall perform his duties.

4. The Secretary shall issue notices of meetings of the Board, record its transactions, and conduct that part of the correspondence relating to the

Board and to his duties. He shall execute all deeds, contracts or other instruments on behalf of the corporation, when duly authorized. He shall have custody of the seal of the corporation and shall affix the same whenever authorized to do so by the Board of Trustees or by the Executive Committee or the Finance Committee.

ARTICLE IV.

EXECUTIVE ADMINISTRATION.

The President.

1. There shall be a President who shall be elected by ballot by, and hold office during the pleasure of, the Board, who shall be the chief executive officer of the Institution. The President, subject to the control of the Board and the Executive Committee, shall have general charge of all matters of administration and supervision of all arrangements for research and other work undertaken by the Institution or with its funds. He shall devote his entire time to the affairs of the Institution. He shall prepare and submit to the Board of Trustees and to the Executive Committee plans and suggestions for the work of the Institution, shall conduct its general correspondence and the correspondence with applicants for grants and with the special advisers of the Committee, and shall present his recommendations in each case to the Executive Committee for decision. All proposals and requests for grants shall be referred to the President for consideration and report. He shall have power to remove and appoint subordinate employees and shall be *ex officio* a member of the Executive Committee.

2. He shall be the legal custodian of all property of the Institution whose custody is not otherwise provided for. He shall be responsible for the expenditure and disbursement of all funds of the Institution in accordance with the directions of the Board and of the Executive Committee, and shall keep accurate accounts of all receipts and disbursements. He shall submit to the Board of Trustees at least one month before its annual meeting in December a written report of the operations and business of the Institution for the preceding fiscal year with his recommendations for work and appropriations for the succeeding fiscal year, which shall be forthwith transmitted to each member of the Board.

3. He shall attend all meetings of the Board of Trustees.

ARTICLE V.

COMMITTEES.

1. There shall be the following standing Committees, viz, an Executive Committee and a Finance Committee.

2. The Executive Committee shall consist of the Chairman and Secretary of the Board of Trustees and the President of the Institution *ex officio* and, in addition, five trustees to be elected by the Board by ballot for a term of three years, who shall be eligible for re-election. Any member elected to fill a vacancy shall serve for the remainder of his predecessor's term: Provided, however, that of the Executive Committee first elected after the adoption of these by-laws two shall serve for one year, two shall serve for two years, and one shall serve for three years; and such Committee shall determine their respective terms by lot.

3. The Executive Committee shall, when the Board is not in session and has not given specific directions, have general control of the administration of the affairs of the corporation and general supervision of all arrangements for administration, research, and other matters undertaken or promoted by the Institution; shall appoint advisory committees for specific duties; shall determine all payments and salaries; and keep a written record of all transactions and expenditures and submit the same to the Board of Trustees at each meeting, and it shall also submit to the Board of Trustees a printed or typewritten report of each of its meetings, and at the annual meeting shall submit to the Board a report for publication.

4. The Executive Committee shall have general charge and control of all appropriations made by the Board.

5. The Finance Committee shall consist of three members to be elected by the Board of Trustees by ballot for a term of three years.

6. The Finance Committee shall have general charge of the investments and funds of the corporation, and shall care for and dispose of the same subject to the directions of the Board and of the Executive Committee. It shall consider and recommend to the Board of Trustees such measures as in its opinion will promote the financial interests of the Institution, and shall make a report at each meeting of the Board.

7. All vacancies occurring in the Executive Committee and the Finance Committee shall be filled by the Trustees at the next regular meeting.

8. The terms of all officers and of all members of committees shall continue until their successors are elected or appointed.

Article VI.

FINANCIAL ADMINISTRATION.

1. No expenditure shall be authorized or made except in pursuance of a previous appropriation by the Board of Trustees.

2. The fiscal year of the Institution shall commence on the first day of November in each year.

3. The Executive Committee, at least one month prior to the annual meeting in each year, shall cause the accounts of the Institution to be audited by

a skilled accountant, to be appointed by the Chairman of the Board, and shall submit to the annual meeting of the Board a full statement of the finances and work of the Institution and a detailed estimate of the expenditures for the succeeding year.

4. The Board of Trustees, at the annual meeting in each year, shall make general appropriations for the ensuing fiscal year; but nothing contained herein shall prevent the Board of Trustees from making special appropriations at any meeting.

5. The securities of the Institution and evidences of property shall be deposited in such safe deposit or other corporation and under such safeguards as the Trustees and Executive Committee shall designate; and the moneys of the Institution shall be deposited in such banks or depositories as may from time to time be designated by the Executive Committee.

Article VII.

AMENDMENT OF BY-LAWS.

1. These by-laws may be amended at any annual or special meeting of the Board of Trustees by a two-thirds vote of the members present, provided written notice of the proposed amendment shall have been served personally upon, or mailed to the usual address of, each member of the Board twenty days prior to the meeting.

MINUTES

OF THE

Fifth Meeting of the Board of Trustees

DECEMBER 10, 1907

MINUTES OF FIFTH MEETING OF THE BOARD OF TRUSTEES.

[Abstract.]

The meeting was held in Washington, at the New Willard Hotel, on Tuesday, December 10, 1907.

The meeting was called to order at 10 o'clock a. m. by the Chairman, Mr. Billings.

Upon roll call by the Secretary, the following Trustees responded: John S. Billings, John L. Cadwalader, Cleveland H. Dodge, William N. Frew, Lyman J. Gage, Henry L. Higginson, Charles L. Hutchinson, Seth Low, S. Weir Mitchell, William W. Morrow, Elihu Root, Henry S. Pritchett, Charles D. Walcott, William H. Welch, Andrew D. White, Robert S. Woodward and Carroll D. Wright.

Absent: Daniel C. Gilman, E. A. Hitchcock, William Lindsay, D. O. Mills, William H. Taft.

The minutes of the fourth meeting were approved as printed in abstract.

The reports of the President, of the Executive Committee, of the Auditor, of the Finance Committee, of heads of departments, and of grantees of the Institution were presented and considered.

Hon. Andrew J. Montague, of Richmond, Virginia, and Mr. William Barclay Parsons, of New York, N. Y., were unanimously elected to fill the two vacancies in the Board.

The trustees unanimously approved the reports of the Subcommittee on Site and Building and of the Executive Committee concerning the Administration Building, and the action taken by these committees in directing the President to enter into a contract for the erection of said building in accordance with the plans and specifications approved.

The Secretary read and presented to the Board the following letter from Mr. Carnegie:

NEW YORK, DECEMBER 4, 1907.

DEAR SIR: I have watched the progress of the Institution under your charge and am delighted to tell you that it has been such as to lead me to add Two Millions of Dollars more to its endowment.

It has borne good fruit and the Trustees are to be highly congratulated. In their hands and yours I am perfectly satisfied it is going to realize not only our expectations, but our fondest hopes, and I take this opportunity to thank one and all who have so zealously labored from its inception.

Very truly yours,

(Signed) ANDREW CARNEGIE.

Dr. R. S. WOODWARD,
President, Carnegie Institution, Washington, D. C.

In response to this letter, the following resolution, offered by Mr. Root, was unanimously adopted:

Resolved, That the Trustees of the Carnegie Institution of Washington express to Mr. Carnegie the appreciation and thanks of the Board upon his generous gift of Two Million Dollars additional endowment for the Institution. The Trustees are deeply sensible of this mark of confidence, which they will endeavor to justify by their further administration of the great fund provided by Mr. Carnegie's philanthropy for investigations, research, and discovery, and the application of knowledge to the improvement of mankind."

It was then further moved that this resolution be spread upon the minutes and that a copy be engrossed and presented to Mr. Carnegie.

After discussion it was voted that it is the sense of the Board that in future the free distribution of the publications of the Institution be confined to centers of information like important libraries, except for copies furnished to members of the Board of Trustees and to authors.

Petitions for the establishment of new departments of research were referred to the Executive Committee for consideration.

After explanation and discussion, the following general appropriations were made for 1908:

Publication fund to be continuously available	$50,000
Administration	50,000
Grants for departments and large projects	379,940
Previously implied grants, new minor grants and research associates and assistants	50,000
	$529,940

The Board adjourned at 1 p. m.

REPORT OF THE PRESIDENT

OF THE

CARNEGIE INSTITUTION OF WASHINGTON

REPORT OF THE PRESIDENT OF THE INSTITUTION

In compliance with the provisions of Article IV of the By-Laws of the Carnegie Institution of Washington, I have the honor to submit the following report on the work of the Institution for the fiscal year ending October 31, 1907, along with recommendations of appropriations for the ensuing year and with sundry suggestions and comments concerning pending and prospective questions presented by the development of the Institution.

Introductory Statements.

This report is the sixth annual report of the Institution and is presented under the following heads:

1. Work of administration.
2. Résumé of work of the year.
3. Publications.
4. Recommendation of budget for the year 1908.*
5. Additional recommendations and suggestions.

WORK OF ADMINISTRATION.

As will be seen from the data given in the following tables, the financial branch of the administrative work of the Institution has grown to considerable dimensions and complexity. Having transactions with many departments and individuals engaged in research, with many firms of architects, builders, and manufacturers employed in works of construction and equipment, and with many firms employed in the varied work of producing publications, a large amount of time and attention must be given to the details which thus arise.

Financial Statement for the Fiscal Year 1906-1907.

In order that the departments of the Institution may render a proper accounting of their expenditures without undue labor or cost, a uniform system of bookkeeping has been devised for them and introduced during the past year. This system is substantially the same as that developed by the Bursar of the Institution for its accounts, and permits an easy issue of a monthly or quarterly statement for a department, similar to the printed

* It has been deemed unnecessary to print this portion of the President's report in the Year Book.

monthly statements issued regularly by the Institution. The accounts of all departments have been audited during the year by the Bursar, and with the approval of the Board of Trustees such annual audit will be continued.

In accordance with a recommendation approved by the Executive Committee, all departmental accounts with banks in which funds are deposited are kept in the name of the Institution, and are subject to draft by the President as well as by the respective directors of the departments. By direction of the Executive Committee, all receipts of interest on departmental deposits in banks are credited to the respective departmental allotments.

The sources of the funds available for expenditure during the past year, and the allotments to the work of administration, to departments, to grantees, and to publications are shown in detail in the following tabular statements:

	Unallotted Oct. 31, 1906.	Appropriation, Dec. 11, 1906.	Revertments, Oct. 31, 1906, to Oct. 31, 1907.	Total.	Allotments.	Balances unallotted Oct. 31, 1907.
Large grants.....	$82,500.00	$443,200	$21,992.92	$547,692.92	$519,785.70	$27,907.22
Minor grants*.....	650.00	73,100	2,381.53	76,131.53	76,131.53	.....
Research associates and assistants...	.....	25,000	400.00	25,400.00	25,400.00	.....
Publication.....	8,515.53	70,000	3,479.08	81,994.61	65,358.99	16,635.62
Administration	9,868.50	50,000	7.10	59,875.60	49,005.25	10,870.35
	101,534.03	661,300	28,260.63	791,094.66	735,681.47	55,413.19

*This includes $2,000 reverted at the meeting of the Executive Committee, January 14, 1907, by reason of the transfer to the fund for research associates and assistants of grant to G. R. Wieland.

The following list shows the departments of investigation to which the larger grants were made by the Trustees and the amounts allotted from those grants by the Executive Committee during the year:

Department of Botanical Research	$25,000.00
Department of Economics and Sociology	30,000.00
Department of Experimental Evolution	26,000.00
Department of Historical Research	18,700.00
Department of Marine Biology	15,000.00
Department of Meridian Astrometry	20,000.00
Department of Terrestrial Magnetism	59,000.00
Geophysical Laboratory	108,500.00
Horticultural Work (L. Burbank)	10,000.00
Nutrition:	
F. G. Benedict	8,000.00
T. B. Osborne	5,000.00
Nutrition Laboratory	102,085.70
Solar Observatory	92,500.00
	519,785.70

The fields of investigation to which the minor grants were assigned, the names of the grantees, and the amounts of the grants are shown in the following list:

Anthropology:	
Dorsey, G. A.	$2,338.61
Archeology:	
American School of Classical Studies:	
Athens	2,500.00
Rome	2,600.00
Astronomy:	
Campbell, W. W.	4,000.00
Newcomb, Simon	5,000.00
Schlesinger, Frank	300.00
Bibliography:	
Index Medicus	13,150.00
Becker, G. F.	1,200.00
Chemistry:	
Bancroft, W. D.	1,000.00
Morse, H. N.	1,800.00
Noyes, A. A.	2,000.00
Richards, T. W.	2,500.00
Engineering:	
Goss, W. F. M.	3,000.00
Geology:	
Chamberlin, T. C.	6,000.00
History:	
Haskins, C. H.	1,000.00
Literature:	
Sommer, H. O.	$2,000.00
Hodell, Chas. W.	250.00
Meteorology:	
Bjerknes and Sandström	1,200.00
Physics:	
Burgess, C. F.	2,500.00
Howe, H. M.	1,000.00
Barus, Carl	1,000.00
Carnegie Institution of Washington	2,000.00
Zoölogy:	
Castle & Mark	500.00
Naples Zoölogical Station	1,000.00
Mark, E. L.	300.00
Hodge, C. F.	500.00
Crampton, H. E.	3,000.00
Duerden, J. E.	500.00
	64,138.61
Unallotted balance transferred to large grants	9,992.92
	74,131.53

The following table shows the fields of investigation, the names of research associates and assistants, and the amounts of their grants:

Field of investigation.	Names of research associates and assistants.	Amount of grants.
Anthropology	Jones, W.	$500
Botany	Account of the work of L. Burbank.	2,500
Chemistry	Baxter, Gregory P.	1,000
Bio-chemistry	Goldthwait, Joel E.	2,000
Geology	California State Earthquake Investigation Commission	500
Paleontology	Hay, O. P.	1,500
	Wieland, G. R.	2,000
Psychology	Porter, James P.	500
Philology and Linguistics	Flügel, Ewald	3,500
Physiology	Loeb, Leo	1,000
	Noguchi, Hideyo	200
Zoölogy	Johnson, R. H.	600
	Transeau, E. N.	600
Total		16,400
Unallotted balance transferred to large grants		9,000
		25,400

The following grants for publication were authorized during the year:

Andrews, C. M.	$3,200.00
Barnard, E. E.	5,000.00
Barus, Carl	208.10
Benedict, F. G.	3,095.63
Bjerknes and Sandström	2,100.00
Burnham, S. W.	3,951.47
California State Earthquake Investigation Commission	8,700.00
Case, E. C.	227.82
Coblentz, W. W.	209.48
Conard, H. S.	700.00
Davenport, C. B.	650.00
Dean, Bashford	1,427.38
Dorsey, Geo. A.	249.74
Durand, W. F.	700.00
Guide to Government Archives in Washington	1,500.00
Hale and Fox	375.00
Hay, O. P.	7,000.00
Hill, G. W.	1,327.76
Hodell, C. W.	4,000.00
Index Medicus reprint, Vol. I, 1903	1,200.00
Index to Public State Documents	$5,000.00
Jones, H. C.	1,718.55
Lloyd, F. E.	2,000.00
MacCurdy and Castle	430.16
MacDougal, D. T., *et al.*	1,700.00
Mayer, A. G.	204.69
Morse, A. P.	89.39
Noyes, A. A.	608.34
Osborne, T. B.	574.44
Parkhurst, J. A.	275.79
Pearl, Raymond	199.33
Pearl and Clawson	494.42
Richards and Behr	220.48
Richards and Forbes	16.60
Richards, T. W., *et al.*	450.00
Richards, T. W.	400.00
Shaw, James B.	1,000.00
Shepherd, W. R.	450.00
Tower, W. L.	1,245.87
Willis, Bailey	2,281.33
Wood and Uhler	177.22
	65,358.99

The sources and the amounts of the revertments during the year are as follows:

REVERTMENTS FROM NOVEMBER 1, 1906, TO OCTOBER 31, 1907, INCLUSIVE.

Large grants:		
Minor grants	$9,992.92	
Research associates and assistants	9,000.00	
Administration	3,000.00	
		$21,992.92
Minor grants:		
Durand, W. F., grant No. 64	381.53	
Wieland, G. R., grant No. 434	2,000.00	
		2,381.53
Research associates and assistants:		
Transeau, E. N., grant No. 442		400.00
Publication:		
Banta, A. M., grant No. 390	36.64	
Burnham, S. W., grant No. 51	241.35	
Hale, G. E., and Fox, P., grant No. 214	1,500.00	
Index Medicus reprint, grant No. 396	62.90	
Jones, H. C., grant No. 379	194.69	
MacCurdy, H., and Castle, W. E., grant No. 393	15.20	
Newcomb, S., grant No. 386	599.13	
Pérez, L. M., grant No. 357	223.60	
Richards, T. W., grant No. 395	74.71	
Richards, T. W., *et al.*, grant No. 392	84.02	
Scripture, E. W., grant No. 302	192.26	
Stevens, N. M., grant No. 377	1.26	
Washington, H. S., grant No. 363	253.32	
		3,479.08
Administration		7.10
		28,260.63

Since the Institution has grown very rapidly from its foundation to the present time, when the enterprises under way not only demand the entire annual income, but also the surplus accumulated during the past six years, it will be of interest to note the aggregate amounts of funds available for expenditure and the amounts devoted to the various branches of work undertaken up to the present time.

Summary of Receipts and Expenditures of the Institution to date.

The aggregate receipts from interest on endowment, from interest on bond investments, from interest on deposits in banks, from sales of publications, from refund on grants and miscellaneous items to date is $2,891,370.66.

The purposes for which funds have been appropriated by the Board of Trustees of the Institution may be summarily classified under five heads, namely: (1) investments in bonds and on account of administration building; (2) large projects; (3) minor projects, special projects, and research associates and assistants; (4) publications; (5) administration. The actual expenditures under these heads for each year since the foundation of the Institution are shown in the following table:

Year ending Oct. 31—	Investments in bonds and on account of administration building.	Large projects.	Minor projects, special projects, research associates and assistants.	Publication.	Administration.	Total.
1902.....	.....	.....	$4,500.00	.....	$27,513.00	$32,013.00
1903.....	$100,475.00	.....	137,564.17	$938.53	43,627.66	282,605.36
1904.....	196,159.72*	$49,848.46	217,383.73	11,590.82	36,967.15	511,949.88
1905.....	51,937.50	269,940.79	149,843.55	21,822.97	37,208.92	530,753.73
1906.....	63,015.09	381,972.37	93,176.26	42,431.19	42,621.89	623,216.80
1907.....	2,000.00	500,548.58	90,176.14	63,804.42	46,005.25	702,534.39
Total..	413,587.31	1,202,310.20	692,643.85	140,587.93	233,943.87	2,683,073.16

*This amount includes an investment of $94,722.22, of the surplus cash account in bonds as follows:
$50,000 Northern Pacific-Great Northern 4 per cent joint bonds, Chicago, Burlington and Quincy Collateral, July, 1921.
$50,000 Lake Shore and Michigan Southern Railway 4 per cent Debenture Bonds.

In brief, therefore, it appears that from the income of the Institution during the past six years there has been spent:

For investments in bonds and on account of administration building.....	$413,587.31
For large projects	1,202,310.20
For minor projects, special projects, and research associates and assistants.	692,643.85
For publication	140,587.93
For administration	233,943.87
Total	2,683,073.16

Some of the large projects were started originally as departments of work, while others have since developed into departments, requiring exceptional

buildings and equipment. The investments in such departments are therefore of a somewhat permanent character, and represent in many cases available assets approximating to the initial costs. Investments in minor projects, on the other hand, represent in most cases no assets available to the Institution, altho it should be observed that a considerable quantity of apparatus and equipment purchased by aid of minor grants to individuals has been, and will continue to be, of good service to productive investigators.

Under the head of administration and large projects there have been expended for real estate, buildings, furniture, and equipments the following sums, which represent permanent or semi-permanent investments:

Administration:		
Site	$63,015.09	
Plans for building	2,000.00	
Furniture	4,237.38	
		$69,252.47
Department of Botanical Research:		
Furniture and library	3,238.86	
Apparatus	4,746.44	
Buildings	11,756.04	
Grounds and fencing	4,753.35	
		24,494.69
Department of Experimental Evolution:		
Furniture and library	4,124.99	
Laboratory	2,144.32	
Buildings	27,935.83	
Field	3,862.04	
		38,067.18
Geophysical Laboratory:		
Office	5,971.64	
Laboratory	39,964.54	
Shop	8,787.48	
Building and site	99,500.00	
		154,223.66
Department of Marine Biology:		
Vessels	10,283.31	
Buildings and docks	7,375.78	
Apparatus	900.39	
Furniture	1,029.60	
		19,589.08
Solar Observatory:		
Buildings, grounds, road, telephone line	86,196.40	
Instruments and shop equipment	155,940.03	
Library	3,524.43	
Furniture and operative equipment	17,309.59	
Hooker telescope	16,634.24	
		279,604.69
Department of Terrestrial Magnetism:		
Office equipment	2,196.77	
Instruments	13,589.88	
Vessel equipment	2,832.49	
		18,619.14
Nutrition Laboratory:		
Office and laboratories	2,317.90	
Site	10,493.45	
Building construction to date	29,925.27	
		42,736.62
		646,587.53

The following tables show the gross sums allotted to large and minor projects since the organization of the Institution:

Allotments for large projects.

Department.	1904.	1905.	1906.	1907.	Total.
Botanical research	.....	$6,000	$33,000	$25,000.00	$64,000.00
Economics and sociology	.....	30,000	30,000	30,000.00	90,000.00
Experimental evolution	$34,250	12,000	21,000	26,000.00	93,250.00
Geophysical research	.....	24,000	105,500	108,500.00	238,000.00
Historical research	.....	14,000	14,450	18,700.00	47,150.00
Horticultural work (Burbank)	.....	10,000	10,000	10,000.00	30,000.00
Marine biology	20,000	15,700	15,000	15,000.00	65,700.00
Meridian astrometry	.....	.....	10,000	20,000.00	30,000.00
Nutrition research	.....	16,000	16,500	115,085.70	147,585.70
Solar observatory	.....	150,000	150,000	92,500.00	392,500.00
Terrestrial magnetism	20,000	25,000	54,000	59,000.00	158,000.00
Tropical exploration	40,000	.....	.....	.....	40,000.00
	114,250	302,700	459,450	519,785.70	1,396,185.70
Revertment of appropriation for tropical exploration					40,000.00
					1,356,185.70

Allotments for minor projects and research associates and assistants.

Subject.	*1902-03.	1904.	1905.	1906.	1907.	Total.
Anthropology	$4,500.00	$3,500.00	$4,000	$4,000	$2,838.61	$18,838.61
Archeology	2,000.00	5,000.00	31,100	9,850	5,100.00	53,050.00
Astronomy	27,000.00	29,625.68	18,000	18,500	9,300.00	102,425.68
Bibliography	16,000.00	16,000.00	10,000	13,600	14,350.00	69,950.00
Botany	13,700.00	9,000.00	5,600	3,800	2,500.00	34,600.00
Chemistry	11,500.00	17,000.00	12,000	9,300	10,300.00	60,100.00
Economics	1,000.00	32,200.00	.....	300	.....	33,500.00
Engineering	8,620.00	5,000.00	.....	.....	3,000.00	16,620.00
Exploration	6,873.92	18,000.00	.....	.....	.....	24,873.92
Geology	21,700.00	26,800.00	8,475	16,775	6,500.00	80,250.00
Geophysics	5,000.00	27,500.00	.....	.....	.....	32,500.00
History	6,500.00	11,350.00	2,750	2,200	1,000.00	23,800.00
Literature	.....	.....	.....	2,000	2,250.00	4,250.00
Mathematics	2,200.00	3,300.00	.....	400	.....	5,900.00
Meteorology	.....	.....	.....	1,200	1,200.00	2,400.00
Paleontology	5,000.00	4,500.00	4,100	375	5,500.00	19,475.00
Philology	.....	7,500.00	8,500	7,500	3,500.00	27,000.00
Phonetics	1,600.00	2,700.00	2,700	1,800	.....	8,800.00
Physics	7,450.00	11,500.00	10,700	2,750	6,500.00	38,900.00
Physiology	17,400.00	10,500.00	.....	1,000	1,200.00	30,100.00
Psychology	4,000.00	1,000.00	.....	1,000	500.00	6,500.00
Zoölogy	32,000.00	23,845.00	23,100	4,900	7,000.00	90,845.00
Total	194,043.92	265,820.68	141,025	101,250	82,538.61	784,678.21

*Of the amounts credited to 1902-03, all were for 1903 except $1,000 for bibliography, $1,000 for physiology, and $4,000 for zoölogy.

These tables show two facts worthy of brief consideration, namely: great inequalities in the amounts devoted to different fields of investigation; and a large preponderance in favor of the physical sciences, including biology amongst the latter. These facts are a subject of much comment and much correspondence, for the conclusion is often hastily reached that they are the result of chance, prepossession, or prejudice. Without attempting here to discuss the varied aspects of this interesting topic, it may be observed that as regards physical science the development of the Institution is closely similar to the development of educational institutions in recent decades. That contemporary society approves this development seems to admit of no doubt, for no combination of fortuitous causes or sinister influences can account for the vast sums now invested by colleges and universities in the cultivation of physical science. It may be observed also that the relative amounts allotted by the Institution to the different fields of investigation reflect in no small degree the consensus of expert opinion as to the relative importance of those fields, or as to their relative availability for research. Moreover, the trend of development of the Institution at any epoch must be expected to conform, to a greater or less extent, to the prevailing intelligent sentiments of that epoch. At any rate, whether favorable to or inimical to progress, such sentiments must be reckoned with. In view of these considerations, which are often ignored in popular discussions concerning the work of the Institution, it appears to be the part of wisdom to pursue chiefly those researches which meet with approval, rather than opposition, from contemporary society. This appears to be, in fact, in line with the natural order of evolution; for without the demonstrated validity and value of the older sciences we could hardly hope for rapid progress in the newer ones.

RÉSUMÉ OF WORK OF YEAR.

It is plain from the foregoing financial statement that the Institution has grown rapidly to the point of requiring its entire income, nearly, to support adequately the enterprises now under way. This growth is equally attested by the rapid expansion of the research work of our departments and by the enlarging needs of the research work carried on by individual investigators. Altho progress in this respect has been, and still is to some extent, in a preparatory way, nearly all branches of the work of the Institution are not only proving highly fruitful already, but they give promise of rapidly increasing productivity in the near future. In fact, this prospective productivity is a subject of some concern, since our departments alone are likely to need all of the available fraction of our income for the proper publication of their researches.

Growth of Work of Institution.

Along with the growth of the research work its range and ramifications have become increasingly extensive, and hence increasingly difficult of com-

prehensive and summary explanation. Attention is therefore invited to the detailed reports of the heads of departments of investigation and to the reports of individual investigators to be found in the current Year Book.

The fields of investigation enumerated under this head in my preceding report have remained the principal fields of research during the past year.

The Larger Projects.

In conformity, however, with the plans outlined in my previous reports and approved by the Board of Trustees at their meetings of December 12, 1905, and December 11, 1906, special laboratory facilities have been provided for certain branches of the work in geophysics and the work in nutrition, which have been carried on under the auspices of the Institution hitherto in a tentative way only.

The Geophysical Laboratory, whose construction was begun in July, 1906, was ready for occupancy by July, 1907. Dr. Arthur L. Day was appointed Director of this laboratory by vote of the Executive Committee at its meeting of January 14, 1907. Brief reference to this laboratory is made in a subsequent part of this report and a full description, with illustrations of it, will be found in the report of Director Day on pp. 85–96.

The construction of a laboratory for studies in nutrition was authorized by the Executive Committee at its meeting of March 11, 1907. Professor Francis G. Benedict was appointed Director of this laboratory by the Executive Committee at its meeting of February 11, 1907. Reference to the site and the construction of this laboratory is made in a subsequent part of this report and also in the report of Professor Benedict on pp. 130–133.

The larger projects, or departments of work, are enumerated alphabetically in the following list, which gives also the names of the directors conducting the researches in the departments, or laboratories, as the case may be:

Botanical Research: D. T. MacDougal, director.
Economics and Sociology: Carroll D. Wright, director.
Experimental Evolution: Charles B. Davenport, director.
Geophysical Laboratory: Arthur L. Day, director.
Historical Research: J. F. Jameson, director.
Marine Biology: Alfred G. Mayer, director.
Meridian Astrometry: Lewis Boss, director.
Nutrition Laboratory: Francis G. Benedict, director.
Solar Observatory: George E. Hale, director.
Terrestrial Magnetism: L. A. Bauer, director.

To this list may be added the work in horticulture carried on in the main by Mr. Luther Burbank, but in a supplementary way also under the auspices of a committee consisting of the President and the heads of the three departments of biological research, as explained in my preceding report.

Referring to the individual reports of the heads of departments for a more adequate account of the year's work in the numerous and diverse fields of departmental activity, the following summary may suffice to show the trend of current progress.

This department is engaged on a series of problems whose elucidation can not fail to be of the greatest interest and value, whether applied to the restricted field of botany or to the broader domain of biology. By means of observation, experiment, and measurement it is proposed to determine, as nearly as may be, the conditions of development, growth, distribution, migration, and variation of desert plants. Thus, in addition to systematic studies of the forms and distribution of these plants, there must be carried on studies of the factors of temperature, rainfall, evaporation, soil moisture, and anatomical and physiological adaptability. The location of the desert laboratory in a country affording a wide range of plant-forms, as well as a wide range of conditions in altitude, temperature, soil-moisture and soil-composition, presents unequaled opportunities for such studies.

Department of Botanical Research.

Along with these lines of work, the anatomical, physical, and physiological researches of the department staff have already resulted in noteworthy contributions to biological science. Among these, reference may be made especially to publication No. 81, in which Director MacDougal gives an account of the production of a new species of plant by an application of chemical fluids to the parent plant seeds during the period of germination. This remarkable achievement must be regarded as one of the noteworthy advances in modern biology. Mention may be made here also of the important contribution of Professor Lloyd, formerly an associate of the department, on the Physiology of Stomata, now in press as publication No. 82 of the Institution. Scarcely less important and promising in their ultimate applications are the descriptive studies of the desert flora by Professor Spalding, the investigations of the physics of plant life by Dr. Livingston, and the histological researches on hybrids by Dr. Cannon. In the last-named work Dr. Cannon has derived valuable assistance from Mr. Burbank, whose unrivaled production of hybrid plants furnishes ample and varied material for the histologist as well as for the horticulturist.

As may be inferred from its name, this department includes a wide range of work and requires a correspondingly large corps of collaborators. During the past year 185 individuals have participated in its work. Its investigations are under the following titles: Population and Immigration; Agriculture and Forestry; Mining; Manufactures; Transportation; Domestic and Foreign Commerce; Money and Banking; The Labor Movement; Industrial Organization; Social Legislation; Federal and State Finance, including Taxation; The Negro in Slavery and in Freedom.

Department of Economics and Sociology.

The names of the experts in charge of these divisions and the abstracts of progress given in the report of the director afford a sufficient guaranty of an abundant harvest from these varied fields of research. Many preliminary results have already been published and many more are forthcoming.

One of the first necessities which confronted this department was that of a systematic search for early as well as recent economic material in the official documents of the several States of the United States. To meet this need the preparation of a classified index of economic material in the State documents has been undertaken for the department by Miss Adelaide Hasse, of the New York Public Library. Three volumes of this important work, namely, those for the States of Maine, New Hampshire, and Vermont, have been issued by the Institution during the past year, and volumes for New York and Rhode Island are now in press.

Department of Experimental Evolution.

The work of this department is progressing favorably along lines explained in preceding reports, the principal problems under investigation being those of heredity in plants and animals. Old as these problems are, it is only recently that their study has risen to the level of the older physical sciences in which measurement and calculation are so advantageously applied. It is now clear, however, that these powerful adjuncts of research may be applied with equal advantage in biological investigations. Thus the more important work of our Departments of Experimental Evolution, Botanical Research, and Marine Biology serves to mark the advance of biological science from the qualitative to the quantitative stage.

One of the most interesting and gratifying results flowing from the larger projects undertaken by the Institution is the stimulus they are producing amongst individual investigators at home and abroad. This is especially the case with the Department of Experimental Evolution, whose location close to the main routes of travel makes inspection of its work somewhat more easy than in the case of other departments. The reciprocal advantages arising from visits to our departments of experts in similar lines of work are of the highest significance. Indeed, it appears not improbable that the indirect results arising from such conferences may prove to be in the aggregate of as great value in the advancement of knowledge as the direct results of departmental investigations.

The Geophysical Laboratory.

The completion and occupancy of the Geophysical Laboratory mark a noteworthy advance in the progress of the novel and difficult experimental work carried on in this department of research. This work was started in a tentative way by Dr. Day, now Director of the laboratory, while he was a member of the staff of the U. S. Geological Survey. The results of his preliminary investigations and the limited quarters available in the Survey building rendered the construction of a special laboratory essential to adequate development and prosecution of the work. Accordingly, as explained more fully in my last report, provision was made by the Board of Trustees at their meeting in December, 1905, for the purchase of a site and for the construc-

tion and equipment of such a laboratory. In compliance with the contract made in July, 1906, the laboratory was completed and ready for occupancy within a year, so that the director and his staff were in possession of their new quarters early in July of this year. At the present writing the equipment of the laboratory is also nearly secured and installed.

Attention is invited especially to a description, with appropriate illustrations, of this laboratory, to be found in the report of Dr. Day on pp. 85–96 of this volume. It may suffice here, therefore, to remark that the building is in many respects no less novel than the work for which it is designed. Substantially tho economically built, nearly fire-proof, admirably situated as regards isolation, elevation, light, and ventilation, it is worthy of inspection by those interested in physical laboratories in general as well as by those interested in the special work to which this one is devoted.

Naturally the time and energies of the staff of the laboratory have been absorbed largely by the duties of construction, transfer, and installation of equipment and by the attendant preparatory work. Several publications from members of the laboratory staff have been issued, however, as explained in the director's report and as recorded on pp. 46–54.

Department of Historical Research.

With many departments devoted to as many different fields of research there must be of necessity a corresponding diversity of aims, methods, and results. It is impossible, therefore, to measure adequately departmental activities by any common standard. This diversity and this lack of common terms of comparison are forcibly suggested in passing abruptly from the physical to the historical sciences. But the work which the Department of Historical Research has entered upon is not so remotely allied to the physical sciences as might at first appear. It is, for example, in one respect, strikingly similar to the work of the Department of Meridian Astrometry; for while the latter has for one of its main objects the construction of a catalog of the positions of the stars for the use of astronomers and navigators, the former has for one of its main objects the construction of a comprehensive series of catalogs of historical documents for the use of historians and investigators in American history.

In addition to the line of work just named, the department serves also as a sort of American clearing-house for the dissemination of historical data and for the promotion of historical research. Thus the guides in preparation to materials of American history found in the archives of Canada, Cuba, Mexico, Spain, England, and other foreign countries, as well as in the United States, seem destined to prove of great aid to a wide circle of contemporary and future investigators in this field of history. A guide to materials in Cuban archives, by Mr. Luis M. Pérez, has been published during the year; a similar guide to materials in Spanish archives, by Pro-

fessor W. R. Shepherd, is now in press; while others are in a forward state of preparation. A revised and much enlarged edition of the Guide to the Archives of the Government of the United States at Washington is also now in type, and will soon be issued.

For an outline of prospective as well as current work under this department, attention may be called to the full report of Director Jameson to be found on pp. 97–105.

Horticultural Work of Mr. Luther Burbank.

The experiments and investigations of Mr. Burbank and the work of preparing a scientific account of his methods and achievements are progressing as favorably as the available division of time and labor will permit. Being necessarily and properly very busy with his own affairs and overburdened by importunities of the public, the amount of time available for conferences concerning the origin and the history of his productions is limited.

Dr. Shull, of the staff of the Department of Experimental Evolution, who is collecting the data for the account just referred to, has been at Santa Rosa for two series of conferences during the year, and plans to spend a portion of each year there until this work is completed. Dr. Cannon, of the Department of Botanical Research, has also spent a portion of the year at Santa Rosa, studying especially the physiology of some of the numerous hybrids developed by Mr. Burbank.

One of the most important results which may be expected to arise from Mr. Burbank's work and from the interest in it taken by the Institution is a general stimulus to scientific horticulture. That contemporary society is ready to appreciate and utilize such a stimulus is a noteworthy sign of the times. Thus, many individual and governmental enterprises are giving attention to the economic advantages to be gained from rationally conducted experiments in this field, while biologists in increasing numbers are devoting their studies to the more recondite laws which govern plant, fruit, and flower developments.

Department of Marine Biology.

As explained more fully in my preceding report, the unique conditions under which this department must carry on its work have led to a similarly unique development, the more essential features of which are the absence of a permanent scientific staff and the closing of the laboratory at Dry Tortugas during the autumnal and winter seasons of the year. But these features do not diminish the efficiency or limit the extent of the work peculiar to the department, since the pelagic life of the region can only be investigated advantageously during the spring and summer seasons.

During the past season, as hitherto, the department has extended its laboratory and collecting facilities to specialists in zoölogical research, eleven such guests having availed themselves of the opportunities afforded at Dry

Tortugas and in the adjacent regions accessible by means of the vessels of the department. Signal aid is thus rendered to investigators in localities whose exploration is often attended by dangers as well as by difficulties.

Publication No. 47, on Rhythmical Pulsation in Scyphomedusæ, by Director Mayer, has been issued during the year, and he has submitted for publication a comprehensive monograph on the medusæ of the world. Manuscript for two volumes of researches by associates of the department is also now ready for the press.

Department of Meridian Astrometry.

The work of this department during the year was mainly devoted to preparations for its larger enterprise of a comprehensive catalog giving accurate positions of all stars from the brightest to the seventh magnitude, inclusive. Amongst these preparations is a preliminary catalog, embracing the precise positions for upwards of 6,000 stars, which has been brought to substantial completion during the year. This will not only be of great service to the department, but it will be of signal aid also to astronomical science in general.

Preparations for the establishment of a temporary observatory in the southern hemisphere are likewise approaching completion. An exhaustive study of the meridian instrument to be used at this observatory has been made, so that its constants and peculiarities may be well known before observations with it are begun.

The exquisite and penetrating precision of modern stellar research is not alone interesting and useful by reason of its applications to geography, geodesy, and navigation. It is illuminating also many recondite questions concerning the constellations, the motions, the masses, and the relative distances asunder of the universe of stars. Some of the possible investigations to which these questions may give rise are referred to in the report of Professor Boss, director of the department.

The Nutrition Laboratory.

In conformity with the provision made by the Board of Trustees at their last meeting for the establishment of a laboratory to be devoted especially to an extension of the physical and chemical investigations in nutrition carried on hitherto under the direction of Professors Atwater and Benedict, steps were taken early in the year to select a suitable site and to prepare tentative plans for the building. Since experiments on men in an abnormal as well as in a normal condition of nutrition are contemplated, one of the first requirements of a site was proximity to hospitals whence pathological cases may be furnished. Among other requirements, those of moderate cost of land and the availability of water, gas, and electric current had to be considered; while favorable climatic conditions and convenience and cost of living for the laboratory staff were important desiderata. After preliminary consideration of this project

by the Executive Committee, the matter was referred to its subcommittee on nutrition, and the latter committee in turn requested the President and Professor Benedict to examine and to report upon the relative advantages of various available sites in the cities of Boston, New York, Philadelphia, and Baltimore. A week's time was devoted to this task, and, after further consideration by the subcommittee, it was decided to locate the proposed laboratory in the city of Boston, on Vila street, near the power-house of the Harvard Medical School.

The site selected was purchased from the Corporation of "The President and Fellows of Harvard College" on March 13, 1907. The area of this site is 14,312 square feet, and the price paid is $10,466.70.

On the date just mentioned Messrs. Shepley, Rutan, and Coolidge, architects, of Boston, were engaged to prepare plans and specifications and to superintend the construction. Preliminary plans were presented by them to the Executive Committee at its meeting of April 8, 1907, and were approved, and the President was authorized to make the contracts and attend to other necessary details. Bids from four independent firms of contractors were submitted early in May, and on May 14, 1907, a contract was entered into with Messrs. Horton and Hemenway to do the work of construction for $68,334, and a similar contract was made with Messrs. Buerkel and Company, of Boston, to supply the heating and ventilating apparatus at a cost of $14,825. These contracts required that the building be completed by February 1, 1908. The construction was begun early in July and the building is now rapidly approaching completion.

Thru the courtesy of the authorities of the Harvard Corporation, the laboratory will be able to secure heat, light, power, and refrigeration, at the cost of production, from the near-by power-house of the Harvard Medical School. The site of the laboratory is also near to existing and contemplated hospitals, and the location appears to be in every way extremely favorable for the prosecution of the arduous researches required to improve our knowledge of the physics, chemistry, and pathology of nutrition.

The Solar Observatory.

The work of this department is still largely in the preparatory stage, and is thus as much a work of engineering as of astronomy. The novelties of construction, equipment, and program of research for the observatory, along with the initial difficulties presented by a mountain site, conspire to make the undertaking a formidable one. In spite of many obstacles, due chiefly to unprecedented precipitation during the past winter and to labor troubles on the Pacific Coast, the work of construction has gone rapidly forward.

The optical parts of the 60-inch reflecting telescope have been made ready for mounting, but owing to the labor strikes at San Francisco the completion of the dome for the telescope may delay its erection until the spring of 1908.

The novel tower telescopic apparatus, part of which is above and part of which is below the ground level, has been substantially completed. This consists essentially of a vertical telescope with a 12-inch objective and 60 feet focal length in combination with a Littrow grating spectrograph of 30 feet focal length, thus furnishing a powerful component in the battery of instruments for direct observations of the sun.

Preparations for grinding, figuring, and testing the 100-inch reflector, whose construction, as explained in my preceding report, was rendered possible by the gift of Mr. J. D. Hooker, have likewise gone forward. A fireproof building for this work has been constructed and the necessary grinding-machine is nearing completion. In the meantime it is expected that the Plate Glass Company of St. Gobain, France, will soon have the large disk for this reflector ready for shipment, since it was successfully cast on August 28th last. In the rough this disk will weigh about 4.5 tons.

Simultaneously with these varied works of construction, daily photoheliographic and spectroheliographic observations have been made by aid of the Snow Telescope. Daily studies of the sun and sun-spot spectra have supplemented these observations, and to them have been added pyrheliometric and solar magnetic measurements, along with numerous laboratory investigations bearing directly on the physical properties of the sun.

Department of Terrestrial Magnetism.

The year for this department has been one of varied activities and one specially fruitful in the quantity and quality of the results attained. The operations have embraced magnetic surveys of the North Pacific Ocean; surveys on land in Alaska, Bermuda Islands, Canada, Central America, China, Mexico, and South Pacific Islands; and office work combined with special observational studies at Washington, D. C.

The ship *Galilee*, used in the magnetic survey of the Pacific, started from San Diego, California, on her third cruise on December 22, 1906. Sailing by way of the Marquesas Islands, Samoan Islands, and Yap Island, she arrived at Shanghai, May 8, 1907. From this point she sailed east to Midway Islands, and thence to Sitka, where she arrived July 14, 1907. Leaving Sitka, August 10, she started on a cruise to the South Pacific by way of Honolulu, Jaluit, Marshall Islands, and New Zealand; returning thence by way of Callao to San Francisco. It is expected that she will complete this cruise about May 1, 1908, when she will be returned to her owners.

Up to September 1, 1907, the *Galilee* had traversed nearly 50,000 miles in the Pacific Ocean along courses where few magnetic observations have been made hitherto. Complete measurements of magnetic declination, dip, and

intensity were secured at intervals of 200 to 250 miles along these courses, as well as at numerous points on islands and at prominent ports. All of the results of this extensive survey available in March of the present year were furnished to the U. S. Navy Department and incorporated in a magnetic chart issued in May last by that department for the benefit of mariners. Important errors in previous charts, amounting in cases to as much as 5° in magnetic declination along some main routes of transportation, were thus corrected.

For an account of the work done at the numerous and widely separated land stations during the year, reference must be made to the director's report to be found on pp. 154–166 of this volume. Similar reference must be made also for an account of the computations and special investigations carried on at the office by Dr. Bauer and his staff. Attention is invited likewise to the annual bibliography for a list of the departmental publications. One of the latter, however, is worthy of special mention and commendation here, namely, a quarto volume of 629 pages, giving the detailed results of the magnetic, tidal, astronomical, and meteorological observations made by Mr. W. J. Peters while serving as a member of the Ziegler Polar Expedition of 1903-1905. Mr. Peters has been in charge of the *Galilee* since January, 1906, and as his duties at sea have prevented him from attending to the publication of his work, the task of editor has been assumed by his colleague, Mr. John A. Fleming. The handsome volume issued under Mr. Fleming's editorship has been published under the auspices of the National Geographic Society by the estate of William Ziegler.

Researches Under Minor Grants.

Many researches begun by aid of minor grants made during the past six years have been carried forward during the current year. Twenty-one volumes giving the results of these researches have been published during the year, and several more are in press. In addition, as may be seen by reference to the bibliography on pp. 46–54, many briefer or preliminary papers have been published in journals.

A list of the volumes issued during the year will be found in the next section of this report. Of the works in press, attention may be called here to a second volume giving the archeological and physiographical results of explorations in Turkestan under the direction of Prof. Raphael Pumpelly; to two works on engineering, on high steam pressures in locomotive service and on the performance of screw propellers, by Prof. W. F. M. Goss and Prof. W. F. Durand, respectively; to the Vulgate Version of the Arthurian Romances, by Dr. H. Oskar Sommer; to a reproduction, with translation and annotations, of "The Old Yellow Book," the source of Browning's "The Ring and the Book," by Prof. Charles W. Hodell; to a monograph on The Fossil Turtles of North America, by Dr. O. P. Hay; to a treatise on dynamic

meteorology and hydrology, by Prof. V. Bjerknes and Mr. J. W. Sandström, of the University of Christiania; and the report of the California State Earthquake Commission.

PUBLICATIONS AND THEIR DISTRIBUTION.

Publications Issued During the Year.

Since the most important index of the productivity of a research institution is found in the quantity and quality of its publications, this field of activity requires special consideration. On the score of quantity, at any rate, it is already plain that our departments are destined to be highly productive, and it is equally clear that minor grants to competent investigators will prove similarly fruitful.

That the work of publication under the auspices of the Institution is growing apace will be seen by the following list of works issued during the year and by the supplementary table showing the number of works issued and the cost of publications for each year since the foundation of the Institution. The list shows that 38 volumes have been issued with an aggregate of 3,428 quarto pages and 6,284 octavo pages, respectively. Moreover, there are now in press 23 volumes.

Year Book, No. 5, 1906. Octavo, VIII + 266 pages, 13 plates.

Index Medicus, Second Series, vol. 4, 1906. Octavo, 1,595 pages.

Reprint of Nos. 2–12, inclusive, Index Medicus, Second Series, vol. 1, 1903. Octavo, 1,252 pages.

No. 5. General Catalogue of Double Stars within 121° of the North Pole. By S. W. Burnham. Quarto, 2 vols. Vol. 1, The Catalogue, LV + 256 (256*a*–256*r*) pages. Vol. 2, Notes to the Catalogue, VIII + 257–1086 pages.

No. 9. The Collected Mathematical Works of George William Hill. Quarto, 4 vols. Vol. 4, VI + 460 pages.

No. 32. Chimæroid Fishes and their Development. By Bashford Dean. Quarto, 194 pages, 11 plates, 144 text figures.

No. 33. Researches in Stellar Photometry. By J. A. Parkhurst. Quarto, 192 pages, 13 plates, 39 text figures.

No. 44. Researches in Experimental Phonetics. The Study of Speech Curves. By E. W. Scripture. Quarto, 204 pages, 13 plates, 138 text figures.

No. 47. Rhythmical Pulsation in Scyphomedusæ. By A. G. Mayer. Octavo, 62 pages, 2 plates, 36 text figures.

No. 48. An Investigation of Evolution in Chrysomelid Beetles of the Genus Leptinotarsa. By W. L. Tower. (Paper No. 4, Station for Experimental Evolution.) Octavo, X + 320 pages, 30 plates, 31 text figures.

No. 54. Research in China. By Bailey Willis and others. Vol. 1 in two parts.

Part I. Descriptive Topography and Geology. By Bailey Willis, Eliot Blackwelder, and R. H. Sargent. Quarto, XIV + 353 + XVI pages, 51 plates, 65 text figures.

Part II. Petrography and Zoology. By Eliot Blackwelder. Syllabary for the Transcription of Chinese Sounds. By Friedrich Hirth. Quarto, pages VI + 355–528 + XVII–XXIV, plates LII–LXIII (including 6 plates of birds colored to life).

Atlas. By Bailey Willis, Eliot Blackwelder, and R. H. Sargent. Folio, 42 maps and 21 other illustrations.

No. 55. A Revision of the Pelycosauria of North America. By E. C. Case. Quarto, 176 pages, 35 plates, 73 text figures.
No. 56. The Energy Changes involved in the Dilution of Zinc and Cadmium Amalgams. By T. W. Richards and G. S. Forbes. Octavo, 68 pages, 10 figures.
No. 58. Variation and Differentiation in Ceratophyllum. By Raymond Pearl. Octavo, 136 pages, 2 plates, 26 text figures.
No. 59. The Pawnee: Mythology (part 1). By G. A. Dorsey. Octavo, 546 pages.
No. 60. Hydrates in Aqueous Solution. By Harry C. Jones, assisted by F. H. Getman, H. P. Bassett, L. McMaster, and H. S. Uhler. Octavo, VIII + 264 pages, 35 plates, 76 text figures.
No. 61. The Electromotive Force of Iron under Varying Conditions, and the Effect of Occluded Hydrogen. By T. W. Richards and G. E. Behr. Octavo, 43 pages, 6 figures.
No. 62. Condensation of Vapor as induced by Nuclei and by Ions. By Carl Barus. Octavo, X + 164 pages, 66 figures.
No. 63. The Electrical Conductivity of Aqueous Solutions. By Arthur A. Noyes, assisted by W. D. Coolidge, A. C. Melcher, H. C. Cooper, Yogoro Kato, R. B. Sosman, G. W. Eastman, C. W. Kanolt, and W. Böttger. Octavo, VI + 352 pages, 20 figures.
No. 64. Variation and Correlation in the Crayfish, with special reference to the Influence of Differentiation and Homology of Parts. By Raymond Pearl and A. B. Clawson. Octavo, 70 pages, 8 figures.
No. 65. Investigations of Infra-red Spectra. III. Infra-red Transmission Spectra. IV. Infra-red Reflection Spectra. By W. W. Coblentz. Octavo, 128 pages, 93 figures.
No. 67. The Fauna of Mayfield's Cave. By A. M. Banta. Octavo, 114 pages, 2 plates, 13 text figures.
No. 68. Further Researches on North American Acridiidæ. By A. P. Morse. Octavo, 54 pages, 10 plates, 1 text figure.
No. 69. Further Researches concerning Atomic Weights of Potassium, Silver, Chlorine, Bromine, Nitrogen, and Sulphur. By T. W. Richards, assisted by Arthur Staehler, G. S. Forbes, Edward Mueller, and Grinnell Jones. Octavo, 88 pages, 4 figures.
No. 70. Selection and Cross-breeding in relation to the Inheritance of Coat-pigments and Coat-patterns in Rats and Guinea-pigs. (Paper No. 8, Station for Experimental Evolution.) By Hansford MacCurdy and W. E. Castle. Octavo, 50 pages, 2 plates, 5 text figures.
No. 71. Atlas of Absorption Spectra. By H. S. Uhler and R. W. Wood. Quarto, 59 pages, 26 plates, 7 text figures.
No. 72. Investigation of Inequalities in the Motion of the Moon produced by the Action of the Planets. By Simon Newcomb. Quarto, VIII + 160 pages.
No. 76. The Compressibilities of the Elements, and Their Periodic Relations. By T. W. Richards. Octavo, 67 pages, 8 figures.
No. 80. Conductivity and Viscosity in Mixed Solvents. By Harry C. Jones, assisted by C. F. Lindsay, C. G. Carroll, H. P. Bassett, E. C. Bingham, C. A. Rouiller, L. McMaster, and W. R. Veazey. Octavo, V + 235 pages, 103 figures.
No. 81. Mutations, Variations, and Relationships of the Oenotheras. (Paper No. 9, Station for Experimental Evolution.) By D. T. MacDougal, A. M. Vail, and G. H. Shull. Octavo, 92 pages, 22 plates, 73 text figures.
No. 83. Guide to the Materials for American History in Cuban Archives. By Luis Marino Pérez. Octavo, X + 142 pages.
No. 84. The Proteins of the Wheat Kernel. By Thomas B. Osborne. Octavo, 119 pages.
No. 85. Index of Economic Material in the Documents of the States of the United States. Prepared for and under the direction of the Department of Economics and Sociology of the Carnegie Institution of Washington. Separate volume for each State. By Adelaide R. Hasse. Quarto.
(Maine), (1820–1904), 95 pages.
(New Hampshire), (1789–1904), 66 pages.
(Vermont), (1789–1904), 71 pages.

Table showing number and aggregate cost of completed publications by years, including the Year Books and the Index Medicus, to November 1, 1907.

Year.	Number of volumes issued.	Aggregate Cost.			Total costs.
		Index Medicus.	Year books.	Other publications.	
1902–03	2	$5,232.82	$1,531.91	.....	$6,764.73
1903–04	13	11,249.90	1,101.71	$4,372.05	16,723.66
1904–05	21	11,179.35	1,629.79	25,697.81	38,506.95
1905–06	19	11,180.03	1,698.56	19,462.37	32,340.96
1906–07	38	12,619.30	2,454.20	60,076.85*	75,150.35
	93	51,461.40	8,416.17	109,609.08*	169,486.65

* Does not include costs of publications Nos. 81 and 85 (Vermont).

Costs of Publications.

The rapidly growing cost of our publications and the rapid increase in the quantity of worthy contributions for publication coming especially from the departments, grantees, and associates of the Institution have led to an extended study of the problems thus presented. In their variety and complexity these problems have world-wide ramifications, and no single institution can hope to secure for itself anything better than tentative solutions in the near future.

As regards the general aspects of this subject, there are indications of overproduction in the line of scientific publications. The world appears to be accumulating knowledge faster than it can be assimilated. Even by aid of the comprehensive bibliographies now issued, it is difficult, if not impossible, for the specialist to become conversant with the current literature of his own field. On the other hand, the standard of excellence in publications is undoubtedly higher now than at any previous epoch, altho it may not have kept pace adequately with the increasing productivity of our times.

As regards the work of publication of the Institution, the principal object in view is that of making known to the world, in an intelligible and in a permanent form, the methods and the results of our investigations; and due regard for economy requires that we seek always to secure the requisite efficiency at the minimum cost. Hence it is a plain duty not only to insist on a high grade of excellence in matter and form, but also to insist on brevity of statement and on elimination of unnecessary, tho artistic, illustrations. It is equally plain, however, that in this, as in many other matters, the Institution finds itself restricted by a great body of dignified precedent and current practice; so that progress toward improvements, in order to be effective, must be expected to proceed slowly.

In the meantime, the Institution is acquiring a considerable aggregate of experience which should prove instructive. Complete or nearly complete data for the items of cost of publication of 81 volumes issued by the Institution are now at hand.

An examination of these items shows that for the limited edition (1,000 copies) of our works the costs of paper, press-work, and binding are quite unimportant in comparison with the costs of composition and illustrations. The supposed extravagance of high-class paper and wide margins, so often referred to, is irrelevant, therefore, in the face of the facts. A formidable item of cost which ought to be eliminated in large part is that for authors' corrections and changes made in the proof sheets. This amounts to 22 per cent of the cost of composition, on the average, in the case of the works for which information on this point has been secured.

Altho the cost per page of the works referred to varies widely by reason of the great variety of subject-matter for composition and illustration, the following average and extreme costs per page are instructive. They include the cost of composition, paper, press-work, binding, and illustrations, if any. In case of works with full-page plates these latter are counted in making up the number of pages whence the averages are computed.

Table showing costs per page of printed books issued.

Character of work.	Average cost per page.	Least cost per page.	Greatest cost per page.	Number of works.
Octavo :				
Plain matter	$3.29	$2.16	$5.32	17
With text illustrations only	5.44	2.69	11.03	16
With text and half-tone illustrations	6.18	4.32	7.70	7
With text and plate illustrations other than half-tones	7.71	4.03	18.75	12
Mathematical work	5.64	5.43	5.76	2
Quarto :				
Plain matter	5.46	3.62	5.86	3
With text and half-tone illustrations	10.85	8.28	11.39	4
With text and plate illustrations other than half-tones	13.36	6.45	17.83	8
Mathematical work	6.31	3.40	10.84	3

To complete the exhibit of the work of publication it remains to explain how and to what extent the volumes of reports, memoirs, and treatises issued by the Institution have been distributed and to state the number and value of these volumes on hand.

Distribution of Publications.

Since January, 1905, these miscellaneous publications have been distributed in accordance with provisional rules adopted at that time and published in the President's report for that year. Summarily stated, the rules referred to permitted gratuitous distribution to a limited list (called omnia list) of about 300 of the greater libraries of the world, to a limited list of addresses furnished by authors of books published by the Institution, and to a limited extent within the discretion of the President.

The rules also provided for the sale of books at prices sufficient to cover the cost of publication and transportation to purchasers. The following table shows the aggregate number of books distributed in these four ways. The figures include corresponding data, so far as available, for the period prior to 1905, and comprise returns up to November 1, 1907:

Table showing statistics of distribution of publications.

Mode of distribution.	Number of volumes.	Percentage of total number.
By omnia list	26,012	54.47
By requests of authors	15,137	31.69
By sales	4,209	8.81
By discretion of President	2,402	5.03
Total	47,760	100.00

Number and Value of Publications on Hand.

Excluding the Index Medicus, there are now on hand, in storage in the Bond Building and in the attic of the Geophysical Laboratory of the Institution, in round numbers, 40,000 volumes. The sale value of these books aggregates about $62,000. Of the Index Medicus there are in storage 1,800 volumes of an aggregate sale value of $8,000. The total value of books now on hand is therefore about $70,000.

ADDITIONAL RECOMMENDATIONS AND SUGGESTIONS.

Gratuitous Distribution of Publications.

In his report for the year 1905 the President indicated that the distribution of the publications of the Institution was likely to present some difficulties. Under provisional rules approved by the Executive Committee in January, 1905, and published in the annual report for that year all publications of the Institution except the Index Medicus are sent free of charge to a list of about three hundred leading libraries of the world. This list was compiled with great care from a much larger list selected by a competent librarian, with a view to include every important library of educational and learned institutions of the world. Pains were taken also to secure as effective geographical distribution as practicable.

In accordance with the same rules, authors, in addition to receiving 25 copies of their works, were authorized to designate 100 addresses to which complimentary copies might be sent by the Institution. The President was also given discretionary authority to distribute gratis 100 copies of any work. The possible maximum free list for any work was thus about 525 copies.

The standard edition of our publications approved by the Executive Committee at the same time is 1,000 copies; and copies not disposed of in the

ways just mentioned were offered for sale at a cost only sufficient to cover the expense of publication and transportation to purchasers.

While the rules referred to have been justified by the necessity which confronted the Institution at the time of announcing some mode of distribution, many difficulties have been met in their application. The most serious of these arise from the importunities of institutions and individuals claiming rights to the free receipt of all our publications or to the free receipt of certain of them. No amount of courteous endeavor or painstaking research into the relative merits of applicants for such favors can overcome these difficulties. The simple fact is that the demand for a gratuitous distribution of the publications of the Institution is much larger than its income can bear. An attempt to meet this demand in a limited way by means of editions of 5,000 to 10,000 copies of our works would require, at the present rate of issue of 25 to 30 volumes per year, a quarter to a half of our income.

Some serious objections have developed also against the liberal terms accorded to authors in the distribution of complimentary copies of their works. One of these objections rests on the charge of favoritism brought against the Institution by many who have not been thus complimented; a second rests on the complaint of book-dealers who, having filed orders for books published by the Institution, find their clients disposed to cancel such orders by reason of the receipt of presentation copies; while a third rests on the fact that complimentary copies and copies for review are finding their way unduly early to the shops of second-hand dealers.

There appears to be but one way, alike equitable and effective, to check the increasing importunities of individuals and institutions for the free receipt of sets of our publications and to avoid the abuses which have arisen from an attempt to deal generously with authors in the distribution of complimentary copies. This way is to limit the omnia list to its present dimensions and to cut down the authors' list to a minimum which will prevent those abuses. The Executive Committee at its meeting of October 23, 1907, authorized such a restriction of the omnia list and the President desires to recommend in the near future a similar restriction of the presentation lists.

Storage and Sale of Publications.

As shown in the earlier parts of this report, the publications of the Institution have accumulated at a rapid rate. Assuming that something like a stable state of affairs is now attained, it would appear that with an appropriation of one-tenth of the annual income for publications an average of 25 volumes per year may be advantageously published. If these are issued in editions of 1,000 copies each, books must be expected to accumulate at the rate of 10,000 to 15,000 volumes per year for some years, unless sales increase more rapidly than during the past three years.

Provision must be made, therefore, for more adequate storage room in the near future. Such room is provided for by the plans for the proposed Administration Building, which it is hoped may be erected within two years. In the meantime use is being made of the available storage room in the attic of the Geophysical Laboratory, where the risk of loss from fire is much less than in the present office quarters of the Institution.

As to the possibilities of sales of publications, it appears plain from a study of existing trade conditions, as well as from the accumulating experience of the Institution itself, that 500 to 700 copies of each volume of our published works will be needed to meet a normal commercial demand; so that to supply the omnia list and the trade our standard edition of 1,000 copies is essential. But to secure this normal commercial demand the Institution must strictly limit the gratuitous distribution of its books and let them pass on their merits thru the legitimate channels of trade. Believing this method of distribution to be the best one in the interests of society as well as in the interests of the Institution, it is hereby recommended for early adoption.

REPORT OF THE EXECUTIVE COMMITTEE.

REPORT OF THE EXECUTIVE COMMITTEE.*

To the Trustees of the Carnegie Institution of Washington:

GENTLEMEN: Article V, Section 3, of the by-laws provides that the Executive Committee shall submit at the annual meeting of the Board of Trustees a report for publication, and Article VI, Section 3, provides that the Executive Committee shall also submit at the same time a full statement of the finances and work of the Institution and a detailed estimate of the expenditures for the succeeding year. In accordance with these provisions the Executive Committee herewith respectfully submits its report for the year 1906-07.

During the fiscal year ending October 31, 1907, the Executive Committee held nine meetings. Printed reports of these meetings have been sent to the members of the Board of Trustees.

Upon the adjournment of the Board of Trustees, December 11, 1906, the members of the Executive Committee met and organized by electing Mr. Wright chairman for 1907, and by voting that Mr. Gilbert, Assistant Secretary of the Institution, act as secretary of the committee for the same period.

The President's report gives in detail the results of the work of the Institution for the fiscal year 1906-07, together with various recommendations and suggestions, and also an outline of suggested appropriations for the fiscal year 1907-08. The Executive Committee hereby approves the report of the President and his recommendations as the report and recommendations of the Committee.

There are also submitted a financial statement and a statement of receipts and disbursements for the year, together with a statement of aggregate receipts and disbursements since the organization of the Institution, on January 28, 1902.

CARROLL D. WRIGHT, *Chairman.*
JOHN S. BILLINGS.
CLEVELAND H. DODGE.
DANIEL C. GILMAN.
S. WEIR MITCHELL.
ELIHU ROOT.
CHARLES D. WALCOTT.
ROBERT S. WOODWARD.

WASHINGTON, D. C., *November* 30, 1907.

* For the Year Book this report is printed in abbreviated form.

Financial Statement, October 31, 1907.

		ASSETS.	LIABILITIES.
Endowment		.....	$10,000,000
Reserve fund and accrued interest		.....	290,876.80
Bonds (original cost):			
U. S. Steel Corporation bonds, 5 per cent	$10,000,000		
$100,000 A., T. & S. Fe Ry. Co. 4 per cent 100-year gold bonds, Oct. 1, 1995		100,112.50	
$100,000 N. P. Ry. Co. Pr. Ln. Ry. and Land Grant gold bonds, Jan. 1, 1997		101,800	
$50,000 N. P. G. N. 4 per cent Joint Bonds, C., B. & Q. Collateral, July, 1921		46,500	
$50,000 L. S. and Mich. Southern Ry. debenture 4's		48,222.22	
$50,000 Canadian Pacific First Refunding gold 4's		51,937.50	
Real Estate and Equipments:			
Administration:			
Site	$63,015.09		
Plans of building	2,000		
Furniture	4,237.38	69,252.47	
Department of Botanical Research:			
Office library	$3,238.86		
Apparatus	4,746.44		
Buildings	11,756.04		
Grounds and fencing	4,753.35	24,494.69	
Department of Experimental Evolution:			
Office library	$4,124.99		
Laboratory	2,144.32		
Buildings	27,935.83		
Field	3,862.04	38,067.18	
Geophysical Laboratory:			
Office	$5,971.64		
Laboratory	39,964.54		
Shop	8,787.48		
Building and site	99,500	154,223.66	
Department of Marine Biology:			
Vessels	$10,283.31		
Buildings and docks	7,375.78		
Apparatus	900.39		
Furniture	1,029.60	19,589.08	
Solar observatory:			
Buildings, grounds, road, telephone line	$86,196.40		
Instruments and shop	155,940.03		
Library	3,524.43		
Furniture and operative	17,309.59		
Hooker telescope	16,634.24	279,604.69	
Department of Terrestrial Magnetism:			
Office equipment	$2,196.77		
Instruments	13,589.88		
Vessel equipment	2,832.49	18,619.14	
Nutrition laboratory:			
Office laboratories	$2,317.90		
Site	10,493.45		
Building (construction)	29,925.27	42,736.62	
Property investment (aggregate cost)		.....	581,572.44
Grants:			
Large		.....	202,917.90
Minor		.....	24,438.58
Research associates and assistants		.....	5,140.85
Publication		.....	62,389.96
Administration		.....	10,870.35
Cash		208,297.50	
Unappropriated fund		.....	25,250.37
		11,203,457.25	11,203,457.25

Statement of Receipts and Disbursements, November 1, 1906–October 31, 1907, Inclusive.

RECEIPTS.		
INTEREST:		
U. S. Steel Corp. bonds	$500,000	
A. T. & S. Fe Ry. "	4,000	
N. Pac. Ry. Co. "	4,000	
N. P. Gt. N. "	2,000	
Central Pacific "	2,000	
L. S. and Mich. S. "	2,000	
Deposits in banks	8,934.05	
		$522,934.05
SALES OF PUBLICATIONS:		
Index Medicus	$3,676.71	
Year Book	56.50	
Miscellaneous	2,292.89	
		6,026.10
REFUND ON GRANTS:		
No. 51	$241.35	
No. 398	403.19	
No. 280	1,513.95	
No. 64	381.53	
No. 459	129.60	
No. 393	38.94	
		2,708.56
MISCELLANEOUS		15.22
		531,683.93
Balance from last report to Trustees, Oct. 31, 1906		379,147.96
		910,831.89

DISBURSEMENTS.		
INVESTMENT:		
Building (administration)		$2,000
GRANTS:		
Large	$500,548.58	
Minor	77,433.65	
Research associates and assistants	12,742.49	
		590,724.72
PUBLICATION		63,804.42
ADMINISTRATION:		
Trustees	$1,046.02	
Executive Committee	1,290.51	
Salaries	26,191.66	
Temporary employees	3,573.58	
Insurance and surety	666.22	
Rent and telephone	3,673.55	
Furniture	506.94	
Office supplies	2,118.88	
Postage, express, etc	3,861.52	
Printing	3,076.37	
		46,005.25
		702,534.39
CASH IN BANKS:		
United States Trust Co., N. Y.	$200,769.25	
National City Bank, N. Y.	4,747.40	
Am. Security and Trust Co., D. C.	2,780.85	
		208,297.50
		910,831.89

Statement of Aggregate Receipts and Disbursements, January 28, 1902–October 31, 1907.

RECEIPTS.		
INTEREST:		
U. S. Steel Corp. bonds	$2,750,000	
A. T. & S. Fe Ry. "	17,000	
N. Pac. Ry. Co. "	16,500	
N. P. Gt. N. "	8,500	
Central Pacific "	6,000	
L. S. and Mich. S. "	8,000	
Deposits in banks	58,818.17	
		$2,864,818.17
SALES OF PUBLICATIONS:		
Index Medicus	$13,837.41	
Year Book	220.95	
Miscellaneous	4,078.60	
		18,136.96
REFUND ON GRANTS		5,634.08
MISCELLANEOUS:		
Organization	$1,825.52	
Sale of furniture	69	
Gas deposit	5.36	
Postage, express, and travel	34.75	
A. G. Mayer	669.70	
Printing and paper	177.12	
		2,781.45
		2,891,370.66

DISBURSEMENTS.		
INVESTMENT:		
Bonds	$348,572.22	
Building (administration)	65,015.09	
		$413,587.31
GRANTS:		
Large	$1,202,310.20	
Minor	579,735.86	
Research associates and assistants	75,409.15	
Special (of 1904–1905)	37,498.84	
		1,894,954.05
PUBLICATION		140,587.93
ADMINISTRATION:		
Trustees	$6,707.70	
Executive Committee	7,948.95	
Advisory Committee	5,859.81	
Honorariums	11,460	
Salaries	115,646.91	
Temporary employees	22,590.22	
Insurance and surety	1,271.12	
Rent and telephone	18,744.79	
Furniture	5,904.63	
Office supplies	7,923.88	
Postage, express, etc	10,577.21	
Printing	11,603.85	
Organization	1,825.52	
Plans and option	5,166.46	
Seal	555.60	
Miscellaneous	70.23	
		233,856.88
INDEX MEDICUS REFUND		86.99
		2,683,073.16
CASH IN BANKS:		
U. S. Trust Co., N. Y.	$200,769.25	
Nat'l City Bank, N. Y.	4,747.40	
Am. S. & T. Co., D. C.	2,780.85	
		208,297.50
		2,891,370.66

REPORT OF AUDITOR.*

WASHINGTON, D. C., *November* 23, 1907.

The Executive Committee of the Carnegie Institution of Washington:

GENTLEMEN: We hereby certify that we have audited the accounts of the Carnegie Institution of Washington for the fiscal year ended October 31, 1907.

The income from the Endowment Fund and from investments has been duly accounted for, and the expenditures have been regularly authorized and are supported by proper vouchers.

The several securities representing the Endowment, Investment, and Reserve Funds have been examined by us and found intact. The investment and reserve funds securities are carried at cost.

Respectfully submitted.

THE AMERICAN AUDIT COMPANY,
(Signed) By OTTO LUERKERT, *Resident Manager.*

Approved:
[SEAL.] F. W. LAFRENTZ,
President.

Attest:
THEO. COCHEU, JR.,
Secretary.

* For the Year Book the Auditor has abbreviated his report.

BIBLIOGRAPHY OF PUBLICATIONS RELATING TO WORK ACCOMPLISHED BY GRANTEES AND ASSOCIATES.

Under this heading it is sought to include the titles of all publications bearing upon the work done under the grants from the Carnegie Institution of Washington. In the list for the past year, as shown below, there may be some omissions, although it has been the endeavor to make it as complete as possible, and in some cases titles may be included which have only an indirect connection with such work. A list of the works published by the Institution during the year will be found in the President's report, on pp. 32–33.

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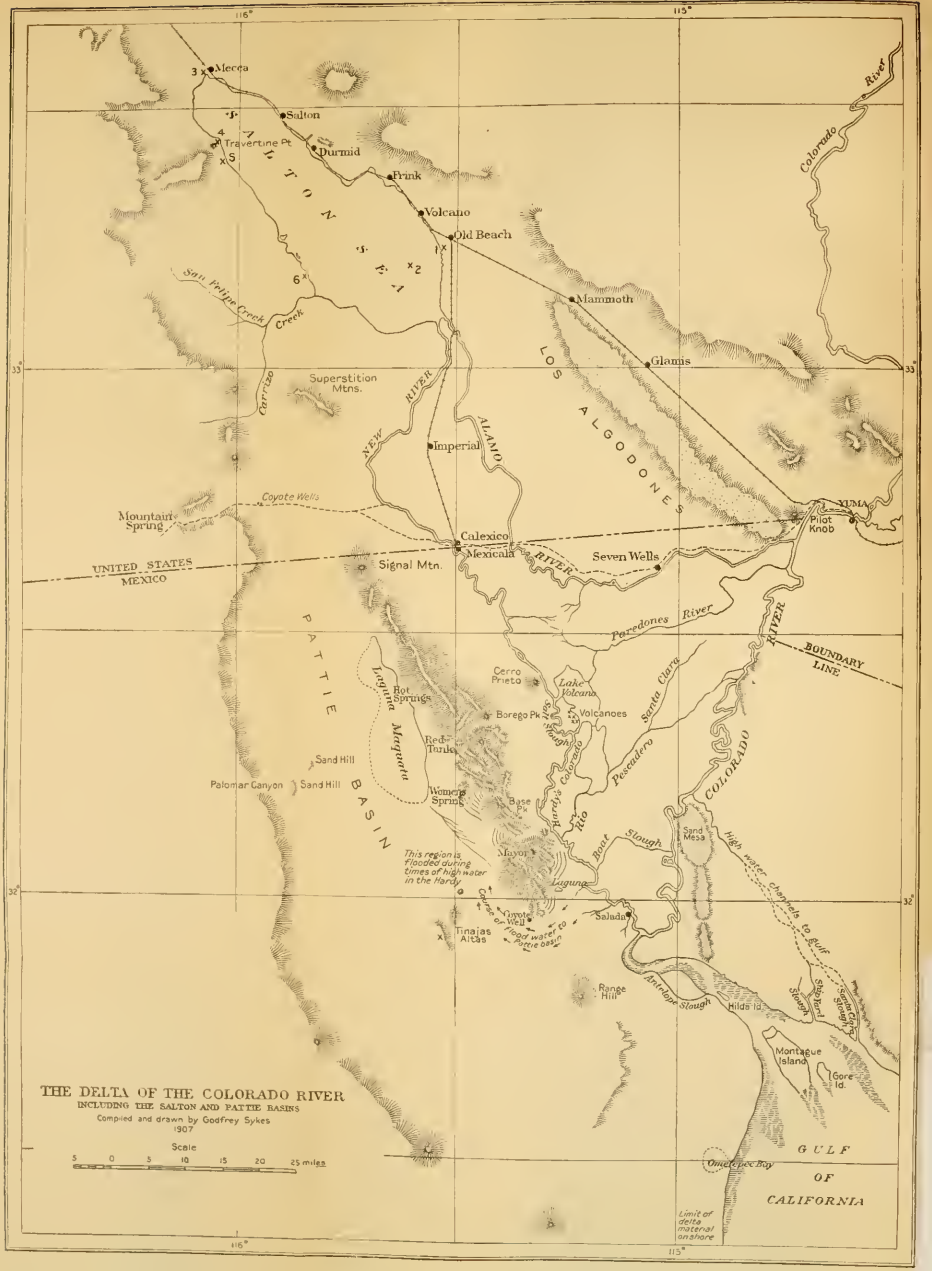
REPORTS ON INVESTIGATIONS AND PROJECTS.

The following reports and abstracts of reports show the progress of investigations carried on during the year, including not only those authorized for 1906–1907 but others on which work has been continued from prior years. Reports of Directors of Departments are given first, followed by reports of recipients of grants for other investigations, the latter arranged according to subjects.


Mecca
Salton
Travertine Pt.
Durmid
Frank
Volcano
Old Beach
Mammoth
Glamis
Colorado River
Salt Pelipe Creek
Carrizo Creek
Superstition Mtns.
New River
Imperial
Alamo River
Los Algodones
Coyote Wells
Mountain Spring
Calexico
Mexicali
Pilot Knob
Yuma
Seven Wells
Signal Mtn.
UNITED STATES
MEXICO
Paredones River
Boundary Line
Cerro Prieto
Lake Volcano
Volcanoes
Borego Pk.
Red Top
Sand Hill
Palomar Canyon
Sand Hill
Mesquite
Womens Spring
Base Pk.
Pattie Basin
Santa Clara
Pescadero
Colorado River
Rio Bonit
Boint Slough
Sand Mesa
High water Channels to Gulf
Mayor
This region is flooded during times of high water in the Delta
Laguna
Salada
Tinajas Altas
Range Hill
Antelope Slough
Hills Id.
Montague Island
Gore Id.
Gulf of California
Limit of delta material onshore
THE DELTA OF THE COLORADO RIVER
INCLUDING THE SALTON AND PATTIE BASINS
Compiled and drawn by Godfrey Sykes
1907
Scale
5 0 5 10 15 20 25 miles

DEPARTMENT OF BOTANICAL RESEARCH.*

D. T. MacDougal, Director.

The resources of the Department and the energy of the staff members have been devoted to the furtherance of the investigations outlined in the report of the preceding year. Substantial progress has been made in the accumulation of data for the development of better-founded generalizations upon all of the problems under consideration. The direct results of such work may be best presented in memoirs dealing with completed researches. Isolated groups of facts and minor generalizations incidental to the main problems are constantly coming to light, however, and these may be most suitably dealt with in briefer articles in various technical and non-technical journals. The editors of such periodicals have been uniformly courteous and prompt in the acceptance and publication of contributions of this character. This may be reckoned as one of the most valuable forms of cooperation rendered the Institution, and greatly increases its facilities for publication.

THE ADVANCE AND RECESSION OF VEGETATION IN THE DEPRESSED BASINS OF THE COLORADO DELTA.

The actual beginning of the study of the movements of vegetation in the Salton and Pattie basins has necessitated a preliminary survey of the areas under consideration. An expedition for this purpose was assembled at Mecca, California, February 5, 1907, and embarked in a sailboat designed and constructed by Mr. G. Sykes, for the circumnavigation of the Salton Sea and an examination of its contacts with the contiguous desert vegetation. The main inflow from the Colorado River was closed while the expedition was afloat, and the maximum level was attained on February 10 or 11, when the area of the lake was estimated as about 500 square miles. (See plate 2.)

Six sections of shore formation were selected as bases from which the succession of vegetation will be followed as the water recedes toward the bottom of the basin. The greatest depth of water found by soundings was 84 feet, and the greater part of the lake will probably disappear in 10 years. As the area occupied by the water is from 5 to 25 miles in width, it may be seen that stretches of beach from a few hundred yards to 2 or 3 miles in extent may become available for occupation by plants during a single season.

Observational area No. 1 comprises a gentle slope of loam, which contained over 3 per cent of alkaline salts, and bore principally *Allenrolfia* and *Sueda,* near Old Beach, on the northeastern shore of the lake (plate 3). No. 2

* Situated at Tucson, Arizona. Grant No. 399. $25,000 for investigations and maintenance. (For previous reports see Year Book No. 2, p. xxvi; Year Book No. 3, pp. 98–100; Year Book No. 4, pp. 126, 127; Year Book No. 5, pp. 119–135.)

includes Obsidian Island, lying offshore from No. 1 about 5 miles southwest and separated from it by a sheet of water with a maximum depth of 30 feet. No. 3 is situated at the extreme northwestern end of the lake and is covered wih a dense jungle of mesquite (*Prosopis*), salt-bush (*Atriplex*), and salt-grass (*Distichlis spicata*). No. 4 comprises the wide floor of a desert wash and adjoining shores near Travertine Point, on the southwestern side of the lake, and bears *Parosela, Gaertneria,* and other plants native to dry soils fairly free from alkali (plate 4). No. 5 lies a short distance to the southward of No. 4, and offers especially good opportunities for the study of the conditions which lead to the development of beach-lines, marked by zones of vegetation, which maintain their individuality many years after the recession of the water. No. 6 includes an area among the sands of Carrizo Creek, characterized by moving crescentic dunes and by stationary mounds moist with saline and alkaline water and bearing numerous small shrubs.

The vegetation now occupying the various sections is largely determined by the amount of soil-moisture and the proportion of salts present, which are chiefly the result of the leaching action of meteoric factors. The submerged areas are of course saturated with the water of the lake, which showed the following constituency in a sample taken from over the deepest part of the lake, June 3, by Prof. V. M. Spalding, which was analyzed by Prof. R. H. Forbes and Dr. W. H. Ross, of the agricultural experiment station of the University of Arizona.

Total Soluble Solids at 110° C.; parts in 100,000.

Sodium	111.1	Aluminum	0.031	Carbonic	6.6
Potassium	2.3	Iron	.005	Silicic	1.2
Calcium	9.9	Chlorine	169.7	Phosphoric	.018
Magnesium	6.4	Sulphuric	47.6		
				Total	364.8

The proportions of sodium, chlorine, and sulphates present are relatively greater in relation to the other soluble solids than in the water of the Colorado River, indicating that other sources, inclusive of the original residue from sea-water and material from the mud volcanoes, are to be considered.

The emersion of the extensions of the observational areas will bare a soil practically uniform in the salts contained, and the restoration of the plant covering found before the inundation must be preceded by the differential leaching and capillary action which previously resulted in such diversity of soil content. The exact observation of these changes in the soil and the accompanying action of vegetation is expected to offer evidence of great value bearing on the factors in the main distributional movements of plants over the surface of the earth.

The level of the lake having fallen about a foot on June 1, 1907, an examination of a portion of the shore line and of observational area No. 3 at Mecca

was made by Professor Spalding. All plants submerged or partly submerged, or included within the moist zone fringing the shore, were found to have been killed, with the exception of *Allenrolfia* and some specimens of poplar. Ten months after the maximum level of the lake had been reached and subsidence had begun, the level had been lowered by 2 or 3 feet, and the strip of saline shore left bare had not been occupied by plants.

A depressed basin in the southwestern portion of the Colorado Delta was explored by the expedition from the Laboratory in February. Flood-water finds its way into the Pattie Basin, nearly every year forming the Laguna Maquata, which oscillates between a maximum level and almost complete dryness with much greater frequency than the Salton Sea or Lake, offering invaluable opportunities for comparative observations at a time when the Department is prepared to deal with the problems involved in a thorough manner.

ACCLIMATIZATION: INDUCTIVE INFLUENCE OF PHYSICAL FACTORS ON VEGETATION.

The plantations for experimental tests on problems of acclimatization have been extended and modified in such manner that the following facilities are now available:

(1) The glass-house, terraces, and inclosed garden, at an elevation of 2,700 feet, in the domain of the Desert Laboratory on Tumamoc Hill.

(2) An inclosure on a small irrigated farm at 2,200 feet, near Tumamoc Hill, the use of which is donated.

(3) The austral plantation, which has been removed from Castle Rock to a suitable locality at 6,100 feet, near Apache Spring, on the Sabina trail to the alpine plantation on the Santa Catalina Mountains.

(4) The alpine plantation, including about 10 acres in Marshall Gulch at 8,000 feet, south of Mount Lemmon and with a northerly exposure. The precipitation is much greater at this station than at the others, where the average is about 12 inches annually. A series of introductions and exchanges is being carried on in these plantations, with marked results in the way of structural changes exhibited by the plants used. Attention is being given to the determination as to whether such impress is confined to the soma of the plant and is non-inheritable, or whether it may be transmitted to successive generations which might be grown in localities other than the one in which the changes originated.

In the measurement of the factors which make up climate a method has been formulated for calculating the thermal exposure of a locality and of the thermal constant of a plant with respect to the various stages of its development. These quantities are quickly obtainable by calculating the area inclosed by a thermographic tracing and the base line of freezing-point of water on the record sheet, and represent hour-degrees of exposure. By this method a meadow was found to receive 78,836 hour-degree units of heat in

a year, while the floor of a hemlock forest near by received but 68,596 hour-degree units, having a season practically 11 days shorter than the meadow in the number of hours above the freezing-point. In the application of this method to a plant with a winter resting season, the exposure is calculated from the solstice, or from the time of planting the seeds until maturity, or until the attainment of some stage of development. Thus the red maple (*Acer rubrum*) was found to need 3,209 hour-degree units to bring its flowers to the stage of opening, while *Draba verna,* in the same locality, required but 1,644 hour-degree units for the same process.

Relative rapidity in changes of temperature, relative humidity, and great difference in the insolation may be held to be accountable for the diversity in plants at various elevations, such as those included by the series of plantations described.

CORRELATED PROBLEMS.

Distribution and Movements of Desert Plants.—Dr. V. M. Spalding has continued his investigations on this subject along the following lines:

(1) An attempt has been made to determine more definitely the physical factors upon which plant-formations are conditioned. The plants of opposite slopes have been compared floristically and numerically, and records of soil and air temperatures in both winter and summer have been made. The data obtained in this way and by determinations of soil moisture may be expected to furnish a realization of the essential features of *aspect* or *exposure* as a factor in distribution. Differences in temperature and amount of water present in the soil appear to be the controlling factors.

(2) The study of limited areas in the domain of the Laboratory for observations upon competition and dissemination has been continued. Many of the new areas have been demarked. Vanishing data in the movements of species and all of the principal facts in these areas are preserved by serial photographs and full records. The setting or general environment of the observational areas has been recorded by a series of maps showing the present actual distribution of characteristic species over the entire domain, which covers 1.33 square miles. This mapping has been largely done by the efficient assistance of Mr. J. C. Blumer, and a large number of dried specimens, constituting a portion of the record, have been prepared by him and also by Prof. F. E. Lloyd.

(3) Data as to distributional movements of the widest amplitude have been obtained by visits to various localities between the Desert Laboratory and the Pacific Ocean, in the deserts of Arizona, the Salton Basin, in the mountains of southern California, and in the coastal region.

Attention is now being turned to a consideration of northward and southward, or vertical, movements, barriers to distribution, and influence of underlying geological formations.

ALKALINE SLOPE IN AREA NO. 1, SHORE OF SALTON SEA, NEAR OLD BEACH, CALIFORNIA.

Variations of Succulents in Volume in Response to Changes in Temperature and Water Supply.—Mrs. E. S. Spalding has continued the series of measurements of the saguaro (*Cereus giganteus*) and prickly pear (*Opuntia* sp.) and now has on hand the accumulated data obtained by the work of four years. Both of the forms exhibit a rapid and marked response by alterations in volume to increase or decrease of the available water in the soil and to loss by transpiration. The flowers of the saguaro show a rate of transpiration much greater than that of any other organ yet examined. The fluted columns of the saguaro also undergo marked mechanical adjustments in response to changes in temperature, and the place of origin of the flower-buds seems to be determined directly by the degree of insolation. It is now possible to express all of the alterations and responses in quantitative form.

The Topography of Chlorophyll Apparatus.—Dr. W. A. Cannon has concluded his anatomical studies on the distribution of chlorophyll in the shoots of desert plants, the principal results being embodied in a paper which will soon be published.

Contrary to the conclusion reached in the earlier stage of the work, it has been established that the depth in the body of the plant at which chlorophyll may persist depends upon aeration and was found to be 6.6 mm. in *Cereus giganteus.* The chlorophyll formed in young stems of *Cereus, Fouquieria, Krameria, Parkinsonia,* and probably *Zizyphys* persists through the life of the plant, while the layer bearing this substance is usually cut off by the formation of cork. The plants studied may be divided into two groups with regard to foliar habits. In one class leaves are rudimentary or wanting; in the other, leaves are formed and retained during the season when the water supply is greatest. The differences in leaf-habit are accompanied by fairly consistent morphological characters in the stems. Plants with reduced leaf surfaces or with no leaves have palisade parenchyma in the cortex of the stems, and this chlorophyll-bearing layer lies near the surface, with no especially developed protective devices in the epidermal tissues. Species with some leaf surface, on the other hand, have only a spongy parenchyma containing chlorophyll in the cortex of the stems, which is more deeply placed than palisaded tissues in plants devoid of leaves. The tissues external to such chlorophyllaceous tissues usually show some protective devices.

Root-habits.—The study of root-habits, made by Dr. Cannon, has been extended to include a large number of cacti, and it appears that none of this group shows deeply penetrating roots. Many species show a profuse ramification immediately underneath the surface, while a maximum depth of 20 inches was found in *Cereus giganteus.*

With the exception of the juvenile storage organs on the roots of *Opuntia versicolor* and the thickened roots of *Opuntia arbuscula,* these organs are generally slender among the cacti examined.

A species of *Orthocarpus* (probably *Orthocarpus purpurascens palmeri*) was found to be parasitic on the roots of about twenty herbaceous plants, on which it exercises deleterious effects.

Determination of Relative Water Soluble Contents of Salt-loving Plants.—Dr. Cannon has ascertained that water extracts of the stems of species growing in saline soils when tested with a Wheatstone bridge give a resistance characteristic of the species, and that this resistance bears a definite relation to that of the soil solution in which the plant customarily grows. These results were confirmed by freezing tests, and also by analyses made under the direction of Dr. W. J. Gies, of Columbia University. The readiness with which the method may be applied suggests that it may be of great value in distributional studies, such as that undertaken in connection with the recession of the Salton Sea.

Comparative Anatomical Studies of Hybrids.—An examination of the origin, development, and final form of the tissues in hybrids and the parental forms has been undertaken by Dr. Cannon. Such an investigation has not as yet been made by modern morphological methods, and it is proposed to carry it out with the exactness with which structures are surveyed in cytological work. It is within the range of possibility that this method may evolve some feasible method of appreciating unit characters, or at least of assisting in the evolution of this conception. Much of the material for this work is being drawn from the plantations of Mr. Luther Burbank, and includes *Juglans, Papaver,* and *Solanum,* as well as *Oenothera* from other cultures.

Physiology of Genetics—Influence of External Agents on Heredity.—A comprehensive description has been previously given of a discovery by Dr. D. T. MacDougal, made in 1905, that reagents of various kinds injected into ovaries of seed-plants previous to fertilization induced breaks in heredity by which some of the progeny derived from treated ovaries differed from the parents in one or more characters. These experiments have been continued and extended. Eighteen separate cases of such treatment, dealing with seven species of five genera, are now under consideration. The earlier results favored the assumption that the various reagents which had been used upon the reproductive elements of plants with the effect described had induced mutations or changes, which had been brought about in the reduction divisions leading to the formation of the egg-cells. In a study of the actual technique of the process, however, it was found that fluids of various kinds injected into ovaries did not in any instance succeed in penetrating to the embryo-sac or the egg-cell. The lining walls of the ovary, however, and the endostomes through which the advancing pollen tubes must pass, were thoroughly permeated with the reagents, and would thus be in immediate contact

with the tube containing the pollen nucleus and attendant structures. These and other facts therefore lead to an amended conclusion that external agents affecting heredity exert this action most readily by influencing the pollen derivatives and not the egg-cells.

Successive generations of the earlier derivatives, notably that of *Oenothera biennis,* have been made with the result that the newly assumed characters have been found fully transmissible and stable in the recently originated line of descent.

Physiology of Storage Organs.—Seeds, bulbs, tubers, and corms of a number of species, which show adaptations for the storage of water, have been accumulated for cultivation, and various experimental tests are under way by which this capacity of the plant may be understood morphologically and as to possible modifications transmissible from one generation to another.

Fasciations.—An investigation of the morphology and heritability of fasciations was begun by Miss A. A. Knox in the New York Botanical Garden in 1906 and completed in 1907. The principal results are ready for publication.

Great differences are found among the deformations of stems known as fasciations, and this diversity is found to depend upon the localization of the injuries to which the deformation is due. The injuries in question were found to be due to the action of the ovipositor of a moth, *Mompha,* in laying eggs, or to the ravages of the larvæ hatched from them.

Stems injured in the center of the apex or irritated there may produce ring fasciations by a spreading of the apical meristem in radial distribution. Those injured on the side may become linear fasciations, and a larger, wider attack of irregular kind produces the protuberances. The time of the attack makes a great difference in the development. If the injury is to the growing region of a biennial plant still in the rosette stage, the plant fasciates during the rosette period, and the growing region becomes linear before the time of the elongation. The stems are then flat from the base. If the plant is adult at the time of the invasion, the injuries are in the upper part of stems which have already completed their first growth. These fasciated stems are round below and flat above. In a given field of plants it will also be noticed that most of the fasciated individuals begin to flatten from the same relative point on the axis. This seems to indicate that the banding is stimulated in all of them at the time of the advent of the new swarm. In an adjoining field, apparently of similar character, the failure of a swarm, or its less penetrating mode of attack, may account for the absence of any degree of fasciation whatever. These modifications were not found to be transmissible in any degree, and hence differ very essentially from fasciations due to internal causes—causes which are themselves transmissible from generation to generation.

Physiology of Stomata.—Prof. F. E. Lloyd brought his work upon the physiology of stomata to a close early in the year and presented a paper which is to be published by the Carnegie Institution as No. 82 of its series of publications. No important modifications of the main conclusions reported concerning this work in the previous year have been made, and the principal results seem to be thoroughly tested and confirmed. Professor Lloyd acted as superintendent of the Desert Laboratory during the earlier part of the year, in place of Mr. G. Sykes, who was detailed for special duty in the construction of a mountain road to the Solar Observatory on Mount Wilson.

Relative Transpiration and Variations in the Rate.—Dr. B. E. Livingston has been engaged in making a general survey in which a number of plants representing various physiological types have been examined with regard to the performance of the transpiration function. A successful effort is being made to discriminate between the physiological and the purely physical variations in the rates of loss of water by plants, by the use of improved methods and of the conception of relative transpiration.

The Relation of Evaporation in the Open Air to Plant Activity.—The experiments of Dr. Livingston in the behavior of plants rooted in moist soil, but subjected to the action of air with high and low evaporating power, have established the fact that such evaporating conditions exercise a very important direct influence on the plant, irrespective of its effect on soil moisture. In order to survive and succeed in dry climates the plant must not only have an adequate supply of soil moisture, but must have developed the power of absorption and the mechanism of conduction to such extent as to supply the transpiring surfaces with the necessary amount of water. A correlative adaptation of course includes the various structures, such as waxy citicula, which restrict transpiration.

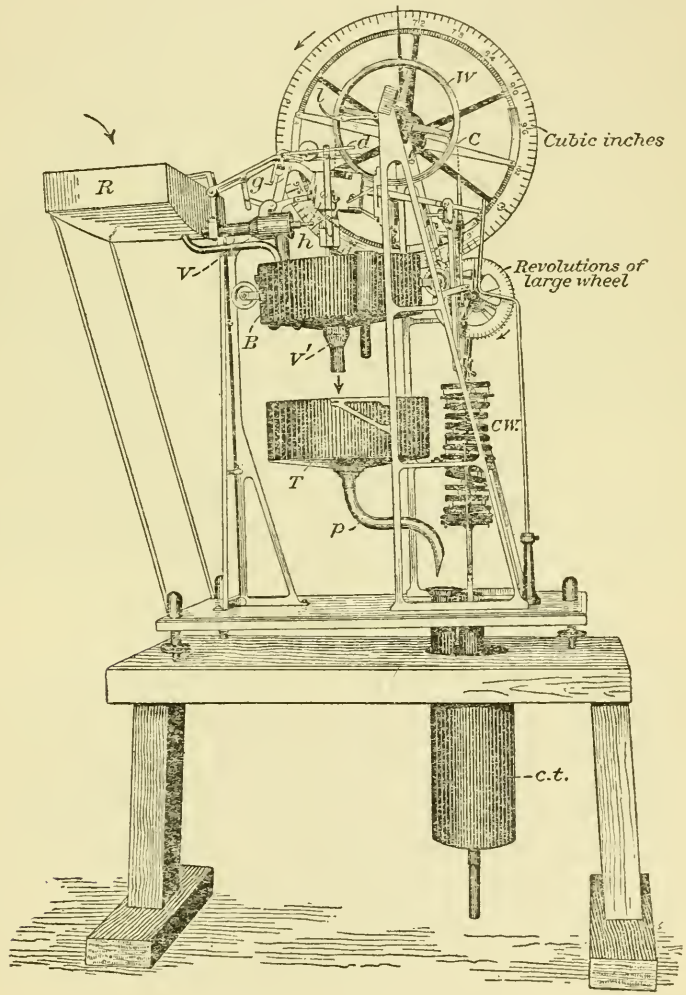
Evaporation and Plant Distribution.—Fragmentary evidence seeming to suggest that the ratio of rainfall to evaporation is perhaps a more decisive criterion for the delimitation of vegetation zones than temperature, arrangements were made by which some comprehensive data might be obtained. For this purpose Dr. Livingston distributed cup evaporimeters to 26 observers in various regions in the United States, and weekly reports were returned to him by the collaborators. The reduction, correction, and comparison of these records is now being carried out. The prompt and active manner in which this cooperative work has been carried out by the various observers has been very gratifying.

Soil Moisture.—Dr. Livingston has continued the series of analyses for the purpose of determining the amount of water available for plants in desert soils during different seasons of the year. So far attention has been wholly directed to the various types of soil included within the domain of the Desert

DESERT WASH IN OBSERVATIONAL AREA NO. 4, OCCUPIED BY AN ARM OF THE SALTON SEA.

Laboratory. The completed work will also embrace a series of comparisons of this feature through a series of seasons.

Automatic Rainmeter.—Mr. H. de Raasloff, C. E., has continued his experimental study of a design for an apparatus which may be taken to the outlying stations of the Desert Laboratory and left to register automatically the rainfall for extended periods of irregular length, perhaps for months. A successful solution has been reached, and one instrument is now installed at the Desert Laboratory, preliminary to the complete organization of the outlying stations. The principle underlying the design is that after it has been



THE DE RAASLOFF AUTOMATIC RAINMETER.

registered the rainwater shall be used to complete the work of the meter, constituting the registration of one bucketful of water. Briefly, the construction and operation of the rainmeter are as follows:

The rainwater collected by a standard funnel flows through a pipe into a reservoir (R) and thence through a valve (V) into a bucket (B) suspended by a chain (C) over a wheel (W). From the other end of this chain are hung a variable counterweight tank (*ct*) which counterbalances the bucket (B) and a series of weights (CW) to counterbalance the water. As the bucket (B) fills, it descends, thereby lifting one by one the counterweights (CW) and the counterweight tank (*ct*), the large dial at the same time registering the number of cubic inches of rainwater at any time contained in the bucket (B). When it has descended sufficiently, a lever (*l*) on the wheel (W) will release a catch (*d*) and a hammer (*h*) will fall, closing the inlet valve (V), opening an outlet syphon valve (V′), and allowing the water to flow into a stationary tank (T). The lessening of the weight of water in the bucket (B) and the pull of the counterweights (CW) will cause the bucket (B) to rise again until it is checked and held temporarily by the hammer (*h*). This assures the complete emptying of the bucket (B) into the stationary tank (T), from which the water flows into the counterweight tank (*ct*). The additional counterweight thus created will cause the bucket (B) to rise still farther, thus pushing up the hammer (*h*) until it is held by the catch (*g*), closing the outlet valve (V′), opening the inlet valve (V), and allowing the accumulated water in the reservoir (R) to flow into the bucket (B) as before. This completes the cycle of the operations necessary to the registration of one bucketful (or about 18 cubic inches) of rainwater. The large indicator wheel revolves and registers as the bucket (B) descends, but remains stationary as the bucket (B) rises. The small indicator wheel registers the number of revolutions of the large wheel.

EXPLORATIONS AND FIELD WORK.

The experimental plantations in the Santa Catalina Mountains form a series, the farthest of which is 32 miles distant from the Desert Laboratory and at an elevation of a mile above it. Several visits are made to these places during every season, necessitating the use of a train of pack-horses for transporting supplies and apparatus. The region traversed is rich in material of importance and the trips are timed to meet the various needs that arise.

In the study of the origin and development of deserts and desert flora much attention has been given to unmapped regions in southwestern Arizona and in the desert areas in and near the delta of the Colorado River. A sailboat has been constructed and designed for use on the Salton Lake, while pack-trains and wagons are used elsewhere. The principal explorations of the year have been made in the Pattie Basin, a depressed area forming a part of the Colorado Delta in Baja California. This region is one of the most arid

in North America and receives an inflow of water at more frequent intervals than the Salton Basin to the northward. Besides establishing the fact that the bottom of this basin is below sea-level, and other features of its relation to the delta, the delta proper has been found to include a low plain to the westward of the northern part of the Gulf of California. In addition to various botanical data obtained in this work, new species of fishes and of various other animals have been brought in. Topographical field notes made by Mr. G. Sykes have served for the compilation of the map accompanying this report.

FEATURES OF NORTH AMERICAN DESERTS.

The efforts toward making a brief survey of the more important arid areas of the continent have been continued, and a brief study has been made of the vegetation and general topography with some attention to the geological history of the regions in question. The demand for the information conveyed in Publication No. 6, prepared by Messrs. Coville and MacDougal in 1903 having been so great that the edition was exhausted, it was deemed advisable to compile the data included, together with the results of more recent field work, bringing the whole out under the title of "Features of North American Deserts." It is expected that this will appear early in 1908. Special attention has been given to the Tucson region, and the section upon the desert of this area has been prepared by Prof. W. P. Blake, by request, and this part of the contribution will be of great value in all researches carried on at the Desert Laboratory.

BIBLIOGRAPHICAL WORK.

A complete card catalogue of the collection of books at the Desert Laboratory has been made by Mrs. Grace J. Livingston, who has continued her valuable work in completion of the titles concerning evaporation.

COOPERATIVE WORK, GIFTS, AND DONATIONS.

The Department has been accorded numerous privileges by various institutions. Laboratory facilities and greenhouse space for experimental work have been furnished for the use of various members of the staff by the management of the Hopkins Seaside Laboratory at Monterey, California, by the Botanical Department of the University of Chicago, the New York Botanical Garden, and by the Missouri Botanical Garden. The last-named institution, through the courtesy of its director, Dr. William Trelease, has loaned numerous books and periodicals for use for short periods by various members of the staff.

In accordance with a request made earlier by the Department, a field party of the U. S. Geological Survey ran a series of levels to the Desert Laboratory and affixed a benchmark to the eastern wall, giving its altitude as 2,663 feet.

Material assistance and advice in various investigations have been received from Prof. R. H. Forbes, director of the Arizona Agricultural Experiment Station, and from Prof. J. J. Thornber, of the same institution; also from Prof. K. C. Babcock, Prof. Cyrus Tolman, Prof. F. N. Guild, and Prof. G. E. P. Smith, of the University of Arizona.

The members of the staff have been able to furnish aid to numerous workers in several branches of science and to accompany many visiting parties in profitable journeys afield.

EQUIPMENT.

The development of the equipment made necessary the design of many new pieces of apparatus, of which the automatic rainmeter by Mr. H. de Raasloff is the most notable. The cup evaporimeter, electric regulator, solar condenser, field still, and other pieces are to be included in the new forms brought into service.

A detachable motor has been secured for the boat used in the Salton Sea investigations, and additional equipment for the pack-train and other furnishings necessary for field work have been provided.

The greenhouse forming a portion of the laboratory has been completed, provided with proper shades, benches, and tables and has been fully occupied throughout the year. Roofs have been placed on the stone reservoirs and the pipe lines from the well and various distributing lines have been completed. The engine and pump have been suitably placed on cement bases and shelters built over them. A gasoline machine has been put in place with a capacity of 75 burners and the gas conducted through the laboratories to the proper points.

A portion of the domain separated from the main body by the road leading to the Laboratory has been fenced, and a fence has been thrown around a small area of alluvial bottom land near by, the use of which is given to the Institution. Upon this has also been erected a structure suitable for sheltering six horses and some gardening equipment.

VIEW OF DESERT LABORATORY WITH PLANT HOUSE.

DEPARTMENT OF ECONOMICS AND SOCIOLOGY,*

CARROLL D. WRIGHT, DIRECTOR.

During the past year this Department has employed something over 185 different individuals in collecting material to form the basis of an economic history of the United States. Considering the inherent difficulties of collecting such material, the work has progressed with fair satisfaction. It does not seem necessary to repeat an account of the works printed prior to the beginning of the present year.

DIVISION 1.—POPULATION AND IMMIGRATION.

Dr. Walter F. Willcox, in charge, has had five persons working with him on various subjects connected with immigration. Mr. E. A. Goldenweiser has completed a work on Russian immigration, which will soon be put into type. The work of Mrs. Mary Robert Coolidge on Chinese immigration is practically completed and ready for publication. Near the end of the present calendar year Mrs. Louise S. Houghton, who has lived in Syria and understands the Syrian language, will have a report ready on Syrian immigration. Prof. A. B. Faust has completed a careful and exhaustive history of the German element in the United States.

Dr. Willcox expects to avail himself of the services of Miss E. G. Balch, assistant professor of economics and sociology at Wellesley College, on the subject of immigration from Austria-Hungary. The articles published by the above-named persons during the year and growing out of their work in the Department of Economics and Sociology are listed in the bibliography in this volume, pp. 46-54.

DIVISION 2.—AGRICULTURE AND FORESTRY.

President Kenyon L. Butterfield, in charge of this work, is conducting some very extensive investigations, and while he and his assistants have much material on the various questions under consideration in his division—some of it nearing completion and almost ready for publication—but little has been printed during the year now closing.

Dr. George F. Wells, who has undertaken, under President Butterfield, the study of the rural church in relation to agricultural development and prosperity, has published, in addition to papers previously reported, the four papers listed in the bibliography in this volume (pp. 46-54).

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*Address, Clark College, Worcester, Massachusetts. Grant No. 400. $30,000 for investigations relative to an economic history of the United States. (For previous reports see Year Book No. 3, pp. 55–64; Year Book No. 4, pp. 160–169, and Year Book No. 5, pp. 158–163.)

Division 3.—Mining.

The collection of material in this division, under the charge of Mr. Edward W. Parker, is approaching completion. There has been completed under him chapters on—

Anthracite Coal, by H. H. Stoek, Scranton, Pennsylvania.
Bituminous Coal, by Prof. W. S. Landis, Lehigh University.
Manganese and Chrome, by Prof. W. S. Landis, Lehigh University.
Petroleum and Natural Gas, by Dr. G. P. Grimsley, Morgantown, West Virginia.
Cement and Gypsum, by E. C. Eckel, U. S. Geological Survey.

Prof. Walter R. Crane, Columbia University, New York, in charge of precious-metal mining, has completed the history, geological distribution, and geological occurrence and production portions of his work.

Mr. Walter Renton Ingalls has completed a work on lead and zinc, and has published in the Transactions of the American Institute of Mining Engineers a "Chronology of lead mining," credit being given for the aid received from the Institution.

Division 4.—Manufactures.

This division perhaps calls for the largest amount of work of any in the list. Dr. Victor S. Clark took charge at a rather late date, and this has prevented any matter being printed as yet, though much has been collected, and Dr. Clark proposes to immediately begin the preparation of the final volumes. His assistants are working industriously and making satisfactory progress.

Division 5.—Transportation.

Prof. B. H. Meyer, in charge of this important division, reports that Alton D. Adams has completed a series of nine papers covering various kinds of pools under the general title of "Railway pooling," and the tenth and final paper is nearly completed. These papers will be printed soon.

Mr. A. L. Bishop, treating of "The State works of Pennsylvania," will publish his complete work during the coming year. A part of this monograph has already been published in the Yale Review for February, 1907, under the title "Corrupt practices connected with the building of the State works of Pennsylvania." The first chapter on "The Granger movement," has been written by Solon J. Buck.

Prof. F. A. Cleveland has practically completed one volume of "The history of railway finance."

Dr. U. B. Phillips' "History of transportation in the southern cotton belt to 1861" is being published by the Macmillan Company for the Columbia University Press. A second volume will deal with "Virginia and East Tennessee." The following paper has already been published, in addition to those previously reported: "An American state-owned railroad—the Western and Atlantic." (Yale Review, November, 1906.)

While little has already been published under this division, eight or nine important chapters are so far advanced that they will appear during the coming year. Professor Meyer reports that he believes satisfactory progress has been made in all lines, and that his various co-workers have been faithful and efficient.

Division 6.—Domestic and Foreign Commerce.

The work in this Department is in very satisfactory condition. Prof. Emory R. Johnson, in charge, reports that he has secured "The history of the organization of ocean commerce" from Dr. J. Russell Smith, whose monograph is completed, but not published.

Dr. Walter Sheldon Tower has completed a "History of the American whale fishery," and his monograph on that subject was published by the University of Pennsylvania in June, 1907.

The "History of American foreign trade" is being vigorously pushed by Dr. S. Huebner and his coadjutor, Mr. G. G. Huebner, seven chapters having been turned in. The entire subject will doubtless be finished within the next two or three months.

A monograph on the "Tariff provisions for the promotion of foreign trade of the United States," by Mr. G. G. Huebner, has been published by the American Academy of Political and Social Science.

Mr. A. A. Giesecke, instructor in Cornell University, has treated the colonial period of American legislation, and the history to 1789 is now finished.

Division 7.—Money and Banking.

Dr. Davis R. Dewey, in charge of this division, reports that he has advanced his collection of material somewhat since last year. No works resulting from his studies have as yet been printed, although three are completed and ready for the press, as follows:

History of banking in Pennsylvania, by J. H. Holdsworth, of the Drexel Institute of Art, Science, and Industry, Philadelphia, Pennsylvania.
The relation of the depreciation of greenbacks to prices and wages, by W. C. Mitchell, of the University of California.
The history of banking in Florida, by Prof. D. Y. Thomas, of the University of Florida, Gainesville, Florida.

Dr. Dewey's work has been embarrassed by the death of Prof. W. H. Isley, of Fairmount College, who had collected valuable notes on the history of banking in Kansas and was planning to make the final draft of his report. His notes in scattered form will be of some use in this division.

In addition to the above, Dr. Dewey has under way eighteen other investigations, and he hopes that at least half of them will be finished during the coming year, and that he will be able to give an increasing amount of time to the work during the coming year with the idea of beginning the final draft.

Division 8.—Labor Movement.

This division is under the charge of the Director of the Department of Economics and Sociology.

Two volumes of "Labor history in the United States" have been completed and will be published by the Macmillan Company. This work has been done in cooperation with the University of Wisconsin and the American Bureau of Industrial Research, under the direction of Dr. Richard T. Ely and Prof. John R. Commons. During the coming academic year two additional volumes will be completed. The volumes now in the hands of the Macmillan Company cover labor conspiracy cases, 1806 to 1842, and documents relating to plantation and frontier conditions. Of the volumes to be completed the present year one covers labor conditions, 1820 to 1840, and one covers the period 1860 to 1880; the fifth volume will cover the period 1840 to 1860.

Miss Edith Abbott has published three papers, the titles of which are given in the bibliography in this volume (p. 46). She has also completed studies of women's work in the cotton mills, woolen mills, and the "boots and shoes" industry, and a statistical study of women's wages, all of which it is hoped will be published in a collected volume with the other studies already published. She has also completed a study of "The origin and early history of child labor in America," and contemplates using that with some other papers in the Journal of Sociology. She has also done a great amount of work on the "Hours of labor, women's wages, etc.," that is not ready to publish.

Dr. Hollander has published a new edition of the bibliography of American trade-union publications.

With the material already collected in this division, I see no reason why the final volumes can not be prepared early the coming year.

Division 9.—Industrial Organization.

Prof. J. W. Jenks, Cornell University, has a number of very able assistants working industriously to complete the various parts of his work, but he has not yet been able to publish any monographs or chapters. His absence from the country on work connected with the United States Government prevented him from beginning his work as early as some of the other collaborators, but he is making excellent progress at the present time.

Division 10.—Social Legislation.

Prof. Henry W. Farnam, Yale University, reported in January that the monograph of Dr. J. L. Barnard on "Factory legislation in Pennsylvania" had been published as volume 19 of the publications of the University of Pennsylvania. Professor Farnam is now in Europe on leave of absence

from Yale, and Dr. Clive Day is in charge of the work. He reports that during the present year no monographs have been published in this division, but Dr. Alba M. Edwards has completed his report on the Marine Hospital Service of the United States, which report is now in manuscript and awaiting publication. The work of this division is being carried on progressively and a vast deal of material has been collected.

Division 11.—Federal and State Finance, Including Taxation.

Prof. Henry B. Gardner in charge. As an auxiliary to the work of this division Dr. Charles C. Williamson has published, in the Columbia University studies in history, economics, and law, "The finances of Cleveland," a work of 266 pages, including a most excellent index. This division, as well as that of Money and Banking, has met the greatest difficulty in securing competent investigators, but its work is well advanced.

Division 12.—The Negro in Slavery and Freedom.

At the time of my last report this division was just being started. It is under the charge of Mr. Alfred H. Stone, of Mississippi, and during the current year has made great progress, but has not yet been able to publish anything. As this is practically a new division and no syllabus has been published heretofore by the Institution, I think it is well for those who are interested in this most important, complicated, and delicate subject that Mr. Stone's syllabus be printed in full as part of this report, and it is herewith appended.

THE NEGRO IN SLAVERY AND FREEDOM.*

The scheme submitted herewith is intended to outline a reasonably exhaustive treatment of the economic life of the American negro without trespassing upon either its political or social aspects. The difficulty of treating the one as separated from the other two is frankly recognized, but the desirability of such a method is believed to more than outweigh the difficulties involved in its execution. In so far, then, as this is possible it would be adhered to. Every care would be exercised to prevent an important economic study from degenerating into anything bearing the least resemblance to a discussion of the so-called "negro problem." We have to do with the negro's contributions to American economic history; with the "problems" which may have been created by his presence we here have no concern.

The treatment would aim to be something more than purely statistical. An effort would be made to interpret the salient features of negro life in terms of their economic significance, both to the race and to the country as a whole. The purpose would be to correlate the negro's economic history with that of the American people along certain broad lines, as, for example, through the cotton industry and in the creation of national wealth and favorable trade balances, as affected by products closely identified with negro labor.

* A Syllabus submitted by Alfred Holt Stone.

I. 1619–1793. *The Beginnings of Slavery, from the Introduction of Slavery to the Invention of the Cotton Gin.*

1. A brief review of the condition of laboring classes during the American colonial period.
2. The introduction of negro slavery into America.
3. The importation of white convicts and indentured servants.
4. The development in the southern colonies of an agricultural system based upon negro slavery. (A brief review of the parallel growth of such system in the West Indies.)
5. Why was such development confined to the southern colonies?
6. Effect of England's colonial system or commercial policy on American slavery.

II. 1793–1860. *Negro Slavery as an Economic System.*

1. The African and domestic slave-trade as related to the increase and distribution of negro population.
2. The place of slave labor in the growth of national wealth. (The development and value of "slave products"—cotton, tobacco, sugar, indigo, and rice—under the slavery system, and the balance of trade as affected by such products.)
3. West Indian competition in such products in the world's markets. (Its importance and its decline; the growth and significance of the American raw cotton monopoly.)
4. The development of American and English cotton manufacturing as related to the growth of the raw product by slave labor.
5. Why was not the South a manufacturing section prior to 1860? (Efforts to utilize slave labor in manufacturing and other industrial enterprises; southern ante-bellum prison systems as related to the training of slaves for such pursuits; beginning and decline of southern manufacturing effort.)
6. The effect of the "slave system" upon the economic life of the Southern States, as compared with the development of other sections of the country. Effect of slave labor on white free labor; was the economic contest between the Northern and Southern States before 1860 a contest between two systems of labor, or between two classes of labor? Between "freedom" and "slavery" or between white and negro labor? (The comparative cost and value of free and slave labor, and of white and negro labor.)
7. The relation between slavery in the Southern States and the distribution of European immigration to America before 1860.
8. The economic status of the American negro in 1860. (The distribution and condition of free negroes, including Canadian and other "free negro" colonies; their wealth; their position in the trades and in business; as owners of real estate and slaves; the attitude of white labor and of labor unions toward free negroes, emancipation and negro competition; State and Federal legislation affecting the economic condition of free negroes; negro benefit societies and similar organizations. Also the distribution of slave population, and its economic position as related to the fields of agriculture and the simpler mechanic arts.)
9. The institution of slavery as administered in the Southern States as a factor in the subsequent economic life of the American negro.

III. 1860–1880. *The Economic Transition from Slavery to Freedom.*

1. The readjustment of the relations between capital and labor after emancipation. (The relations between landlord and tenant.)
2. The economic purpose and operation of apprenticeship and vagrancy laws in the evolution of free negro labor. (To include a comparative review of such laws in the West Indies, and of "gradual emancipation," the indenture and coolie systems, as related to such evolution.)
3. The Freedmen's Bureau as a factor in the evolution of negro labor. (A brief review of the Freedmen's Bank to be included.)
4. The immediate economic effect of emancipation, as indicated in the production of southern agricultural commodities during the period of readjustment. (Brief review of effect in West Indies.)
5. The economic significance of the "Kansas exodus" of 1879–80.
6. The end of an era of unrest.

IV. 1880–1908. *The Era of Industrialism.*

1. The rise and development of the negro industrial school.
2. The effect of negro industrial schools, with particular reference to local economic conditions.
3. The development of the negro land-owner.
4. The negro and the labor union; the attitude of white labor toward the negro in the trades.
5. Negro labor in manufacturing industries.
6. Southern prison systems in relation to the economic life of the negro.
7. The negro and foreign immigration to the Southern States; the problem of white competition.
8. The beginning of cooperative effort; negro business institutions; land syndicates; banks; benefit orders, etc.
9. The present economic status. (Property holdings; position as to skilled labor; census data and Federal and State labor bureaus reports; laws; crop lien, labor agents, etc.; the importance of agriculture and land ownership to the negro; the efforts at "colonization" and segregation in Southern and Western States, and condition of such segregated groups, etc.)

In addition to the foregoing a subcommittee of the Department, consisting of Prof. H. B. Gardner, of Brown University, and Dr. Davis R. Dewey, of the Massachusetts Institute of Technology, and having in charge the preparation of an index of economic material in documents of the States of the United States, has done some most excellent and satisfactory work. The indexing of the documents is in charge of Miss Adelaide R. Hasse, librarian of the department of public documents of the New York Public Library. Probably no better person could have been selected for this very important work. The committee reports that there is little doubt that the work of compilation will be practically completed July 1, 1908, according to her agreement; and the expense of compilation has been running below the estimate which Miss Hasse submitted at the time the work was undertaken. The indexes for Maine, New Hampshire, and Vermont have already been printed, and several other States are practically ready for the printer. In all probability Miss Hasse will furnish material as rapidly as the Institution can print it. Many very commendatory references have appeared, and I believe that this work of the Department of Economics and Sociology will prove one of the most valuable and interesting of all it has undertaken to do.

DEPARTMENT OF EXPERIMENTAL EVOLUTION,*

C. B. DAVENPORT, DIRECTOR.

The work of the Department during the past year has continued along lines already laid down in previous reports. The direction that our work has already taken has been determined by the conviction that the most important definite question to answer is: How may the course of the stream of germ plasm that has come down to us from remote ages be controlled in its onward course? This has led us to start a certain number of strains with the intention of controlling their onward progress, first by controlling all matings, and, secondly, by controlling or at least observing the environmental conditions. The number of these controlled strains now at the Station amounts to several hundred, of which 20 are in mammals, 60 in poultry, 15 in cage-birds, about 5 in crickets, 6 in the fly *Drosophila,* 5 in *Crioceris,* a dozen other strains in insects, and over 400 in flowering plants. In some cases the controlled strains extend back for four years, and in the case of rapidly breeding flies for 20 generations. While in most cases the strains have been subject to varying environmental conditions resembling those met with by the wild species, in a few cases we have attempted to control certain factors of the environment, particularly temperature. Such then, in broad outlines, is our work—a work that necessarily demands much time for results. Nature is in no hurry, and for most animals and plants it takes a year to make a single onward step. The administrative work referred to at the end of this report is all directed toward the maintenance and the study of these strains and the study of their environmental conditions.

REPORTS ON SCIENTIFIC WORK.

Heredity in Poultry.—C. B. Davenport.

In the work with poultry 55 of the strains of 1906 were continued and 5 new ones started. Approximately 15,000 eggs of known parentage were incubated and 3,618 chicks hatched. Some of the subjects upon which the breeding experiments in progress are expected to throw light are:

(1) The inheritance of abnormalities, such as cerebral hernia, polydactylism, syndactylism, winglessness, taillessness, etc.
(2) The inheritance of fluctuating variability; increase of red in plumage, of split in comb, of nostril height, of egg-laying; decrease of comb; increased length of tail.
(3) The inheritance of strong *versus* weak characters, as in polydactylism.
(4) The inheritance of special plumage marking, such as barring, spangling, mottling, and blue.
(5) Inheritance in hybridization of localized pigment pattern.
(6) The analysis of the components of the fowl's comb.

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* Situated at Cold Spring Harbor, Long Island, New York. Grant No. 397. $25,000 for investigations and maintenance. (For previous reports see Year Book No. 3, pp. 23–32; Year Book No. 4, pp. 87–107, and Year Book No. 5, pp. 92–105.)

(7) Purity of extracted recessives and dominants.
(8) Creation of new "pure" races.
(9) Fixation of characters by contamination.
(10) Reversion, or the appearance in hybrids of ancestral characters.
(11) Transfer of qualities from one sex to the other.
(12) Comparative effect of reciprocal crosses.
(13) Effect of inbreeding.

Heredity in Canary Birds.—C. B. Davenport.

Of cage-birds, 94 canaries and various hybrids between canaries and finches were hatched. Song sparrows, Java sparrows, and Australian grass parakeets were only partially successfully bred. It is proposed to extend this work slightly. Meanwhile a report on the work done so far is in press. The principal result, apart from determining the presence in these birds of Mendelian unit-characters, is the discovery that the yellow canary bears a mottling factor. This accounts for the mottling of the offspring of the yellow and green canaries and also for the extraordinary variability of hybrids between the canary and other species of finches. Also, a simple explanation is given for a case of "reversion" in canary hybrids referred to by Darwin.

Breeding Strains of Plants.—George H. Shull.

The cultures designed to elucidate the laws of variability and inheritance of characters in plants have materially forwarded the solution of the problems outlined in previous reports. In addition to those problems, the attempt is being made to analyze the complex color variations in the Shirley poppy, a garden derivative of the little red *Papaver rhœas* of the English fields. For this purpose careful descriptions of over 50 specimens were recorded by means of a spectrum scale, and all were crossed upon a single mother plant. Self-fertilization, which supplies the most advantageous method in many cases of this kind, is impracticable in the case of the Shirley poppy, because it is rare that any good seed is secured by this means.

The scope and extent of the pedigree-culture work with plants may be summed up in the following tabulated list of species, which have been under observation during the year:

Species.	No. of separate pedigrees.	Total number of individuals.	Species.	No. of separate pedigrees.	Total number of individuals.
Aquilegia canadensis...	2	7	Oenothera cruciata....	1	170
Bursa bursa-pastoris....	6	850	Oenothera gigas.....	3	99
Bursa bursa-pastoris × heegeri.....	2	630	Oenothera lamarckiana	15	920
Bursa heegeri.....	1	24	Oenothera lata.....	2	21
Bursa heegeri × bursa-pastoris.....	2	2,231	Oenothera nanella	1	96
Erigeron ramosus.....	2	125 (?)	Oenothera rubrinervis .	5	306
Gaillardia	5	26	Papaver rhœas.....	1	53
Helianthus annuus.....	15	1,163	Phaseolus vulgaris. ...	250 (?)	3,000 (?)
Lactuca canadensis.....	4	142	Trifolium hybridum...	4	140
Lychnis alba.....	83	4,023	Verbascum blattaria...	5	220
Lycopersicon lycopersicon.....	4	80	Viola arvensis.....	3	105
Lycopersicon solanopsis	2	29	Zea mays.....	28 (?)	2,000 (?)
			Total.....	446	16,460

From October 15, 1906, until January 4, 1907, and from February 11 until June 10, 1907, I was absent from the Station on account of the work undertaken by the Institution relative to Mr. Burbank's valuable horticultural operations. During these periods the above-mentioned pedigree cultures were under the care and observation of Dr. E. N. Transeau.

Breeding Strains of Insects.—F. E. Lutz.

Much time during the past year has been spent in studies of heredity with *Drosophila ampelophila* as material. As yet, the work on the inheritance of the duration of the egg-larval and pupal periods has not yielded definite results. The same is true of the activity of response to light. A morphological character—abnormal wing-veins—has proved to be inherited in a very interesting fashion. A preliminary account of this latter piece of work was given at the Seventh International Zoological Congress. It is hoped that a final report will be possible shortly.

The breeding of *Gryllus* was quite successful this season, and 125 pairs have been mated for next season's work. It was found this season that the inheritance of the dimorphic wing-length is not a case of simple Mendelism, as had been supposed, and many of the new matings have been arranged with reference to this character. A new form, having aborted tegmina, wings, and ovipositor, has appeared in my pedigreed stock. The inheritance of this condition is being tested. Male crickets usually have the right tegmen overlapping the left, but some maintain the reversed position. The inheritance of the unusual position is being tested. A somewhat similar character is found in man. When the hands are clasped together there is usually a perfect constancy as to which thumb is uppermost; but some people always put the right uppermost, others the left. I hope to find out if this character is inherited and, if so, what laws are followed.

The work with *Crioceris, Hyphantria,* and *Spilosoma* has been continued, but it has not been pushed vigorously on account of lack of time.

Cell-studies in Heredity.—Anne M. Lutz.

The greater portion of the past year has been occupied with the study of the somatic cells of the Oenotheras, which was undertaken as a preliminary to future work upon the germ-cells. This has proven a subject of such unexpected interest, however, that work will be continued, for the present at least, upon somatic tissue exclusively. An exceptional opportunity is offered for such work at the Station for Experimental Evolution, inasmuch as pedigreed cultures derived from pure-bred seed obtained from de Vries and MacDougal have been under cultivation here for three generations. Work was begun upon the growing root-tips of pot-bound greenhouse plants in the rosette stage, and the following forms have been studied and were reported upon at the Seventh International Zoological Congress:

Self-fertilized: Oenothera lamarckiana, O. gigas, O. lata.
Arose from self-pollinated O. lata: O. nanella, O. oblonga, O. lamarckiana.
Open pollinated: O. rubrinervis, O. lamarckiana.
Guarded hybrid: O. lata × O. gigas.

Dr. MacDougal gave us the *lata, nanella, oblonga,* and *lamarckiana,* above referred to, all of which were first-generation offspring of self-pollinated *lata* arising as a mutant from *lamarckiana. O. lata* was of especial interest,

inasmuch as it was probably the only self-fertilized *lata* under cultivation in America at that time.

Two points of especial interest have been brought out by these preliminary studies: First, the large number of chromosomes found in pure-bred *O. gigas* arising as a mutant from *O. lamarckiana* (*lamarckiana,* 14; *gigas,* 28), Second, the strong indication of variation in the number of chromosomes of the somatic cells of each species studied. A large number of pure-bred *Oenothera* seedlings are now growing in the greenhouse for the study of chromosome variation during the ensuing year.

Variation and Heredity in Coccinellids.—Roswell H. Johnson.

The removal, in March, of my breeding experiments with coccinellids from an inadequately heated and lighted room in the main building to the newly completed vivarium was sorely needed. Many new pedigrees were started at that time from the variations found in a large lot of living beetles taken from a hibernating mass on a hill-top in eastern Washington. These were successfully bred until August, when excessive humidity caused many deaths. It may be possible to avoid this another season.

While the increased facilities for providing food make it possible to raise many more beetles, the labor of the daily individual feeding of any considerable number of these carnivorous insects becomes a serious item. This feature, together with the difficulty of keeping the aphid supply at all times adequate, will restrict breeding operations with the carnivorous coccinellids, hereafter, mainly to the testing and interpretation of the variations found. Studies on heredity involving many consecutive generations will therefore be carried on with the less interesting leaf-eating coccinellid genus *Epilachna* and the leaf-eating spotted chrysomelid genus *Chelymorpha.*

I published in the Entomological News for May, 1907, an article entitled "Economic notes on aphids and coccinellids." Besides various notes, this contained a list of aphids on previously unrecorded hosts, found in seeking available food for the beetles. This data is of value to economic entomologists, and was separately printed. The principal results up to August, 1907, were briefly presented in a paper on "Heredity in color pattern in coccinellid beetles" at the Seventh International Zoological Congress. The main points of this paper follow:

Hippodamia convergens is found throughout the United States. In various regions, however, it is accompanied by varieties characterized by decided differences in elytral coloration. For example, in the lower altitudes of California the associated variety has spotless elytra. The species and its variety are in direct competition and regularly interbreed with little or no assortative mating, yet by alternative inheritance the variety resists assimilation and maintains its identity. In this case imperfection of dominance leaves a trail of individuals with spots impaired, yet the segregation in the second generation saves the variety. Without the direct evidence of witnessing the origin of these forms by mutation, we may nevertheless conclude that evolution is taking place here by that process. A further consequence is that these striking differences in color pattern are without selective values, else the varieties would have been eliminated or have replaced the parent species. Knowing these things, the otherwise extraordinary result that some *H. quinquesignata* females from the mountains gave me young *H. lecontei,* as well as *H. quinquesignata,* can be understood. I find that *H. quinquesignata* and *H. lecontei* have similar ranges and often interbreed. Intergrades in nature and in the

laboratory are very rare. The inheritance is Mendelian, *H. quinquesignata,* the darker form, being dominant. This makes it desirable to consider *H. lecontei* a variety of *H. quinquesignata.* The attempt to cross typical specimens of *H. lecontei* with *H. convergens* has always met with failure, except with one pair, where a very small percentage of the eggs developed. However, an abundance of fertile eggs are obtained in crossing *H. convergens* with specimens of *H. lecontei* having some deficiency of pigment, in that respect approaching the much lighter *H. convergens.* Apparently the true gap between *H. convergens* and *lecontei* is a physiological one. Judging by pattern alone, some individuals, really extremes of *H. convergens* approaching *H. lecontei,* may be wrongly taken to be *H. lecontei.* Breeding alone can discover the true condition. This throws light on the distribution of *H. glacialis,* which species has a pattern differentiated by certain losses and coalescences from its closest ally, *H. convergens,* with which, however, it is intersterile. It is found commonly only in the northeastern United States and northward. Yet, in large series, one sometimes finds specimens that technically comply with the description of *H. glacialis,* but which are far too rare to be able to find mates and maintain their existence. Breeding tests convince me that those are really in the *H. convergens* intergenerating unit, and that to regard them as *H. glacialis* upsets any true conception of the geographical distribution of that species. Such a conclusion is of course unfortunate for the taxonomist, but I see no escape.

A series of species and varieties of another section of the genus *Hippodamia* have been described from the Western States, characterized by a black line along the sutural margin of the wing-cover and various degrees of longitudinal coalescence of spots. Another series has the corresponding degrees of longitudinal coalescence of spots, but lack the long black line along the suture. One would naturally, in projecting the phylogeny of these beetles, arrange them in two parallel lines in the order of degree of coalescence; but in taking females from nature the progeny show us that the black line along the suture is a unit-character not preventing the common intercrossing of these two series. The phylogeny must be construed, therefore, as taking place in an interlacing manner rather than in two parallel lines.

Adalia frigida is found in a number of varieties, several of them often in association. Females of one variety from nature have in my experiments given under the same conditions four of these varieties. From a network of coalescent spots to spotlessness there is a series of steps, or, to use Galton's illuminating expression, "positions of organic stability," into one of which these beetles develop in spite of intercrossing and the non-utility of the pattern. In Europe and parts of this country, where *A. bipunctata* has been introduced, one occasionally finds Adalias which have the pigment very much extended, but leaving some of the reddish ground-color in a characteristic pattern. This interbreeds with *A. bipunctata* and yet holds its entity by alternative inheritance. I have found this same pattern in eastern Washington with our native *Adalia* and far from any *A. bipunctata.* This, with other records, shows that it has arisen independently from this species. An independent appearance in two species of the "extensa mark" referred to below, of longitudinal fusions, transverse fusions, and spotlessness in several genera or species in this family points strongly to the determinate nature of the mutations or variations, such as we have in orthogenesis. From the evidence found, polyphyletic origins of varieties and species must be far more common than generally supposed.

De Vries has contended that varieties are characterized by the dropping out of a unit character, and are hence retrogressive; that it is these cases which show Mendelian inheritance. Progressive steps, he contends, take place in several characters at once and are not inherited in a Mendelian way. So many of the characters which give Mendelian inheritance can be explained as an "unpacking" or dropping out that this position of de Vries has received much favor. One who holds to this view is inclined to explain any apparent progressive character which has Mendelian inheritance as being a reappearance of an ancestral character, or, by a convenient logical device, the loss of an inhibiting factor. I have been interested, therefore, in finding one character having Mendelian inheritance which seems to be incapable of being thus explained away.

The coccinellid pattern is made up of a few definitely placed spots or coalescence of these spots into bands or vittæ. *Hippodamia extensa* is one of the few exceptions. This form must be considered a variety of *H. convergens,* because it occupies a part of the range of that species and regularly interbreeds with it. The *extensa* pattern is dominant to *H. convergens,* although some heterozygous individuals show some dilution of the pattern. In *H. extensa* a spot is replaced by a large and characteristic mark, covering the position of the spot and considerable of the space in front of and to the side of it. If a large number of specimens be examined, however, the extreme fluctuants in the direction of reduction of pigment show that this mark consists essentially of a new crescent-shaped pigment center in front of the spot referred to. I know of no spot in this position nor of this shape in all the family, except that on one individual of *H. glacialis.* We must have, therefore, in this mark a truly progressive Mendelizing characteristic.

Certain environmental features are capable of modifying the parts of the soma of some species when applied to the prepupa and pupa. The distinction between the various factors which can or can not modify and also between the parts which can or can not be modified, seems curiously arbitrary. The solution must lie with the students of biochemistry and physiology. To the evolutionist this susceptibility of a part of one species to an environmental feature and the insusceptibility of the same part in another is an enlightening consideration. At least one of my experiments favors the view, for which Tower's experiments give such strong evidence, that the germ and soma are sometimes modified in a parallel way by an environment, so that the result is an inheritance of the acquired character, which has arisen blastogenetically. *H. convergens* subjected to cold in the prepupal and pupal stages has given a pronotum that is characteristic of the mountain species of this genus, which are closely allied. Yet this feature is hereditary in the mountain species when bred in our vivarium. Since it is of no utility, it doubtless arose in response to the environment in both germ and soma.

Without entering into further details, the results obtained support the following views with respect to the evolution of the color pattern in these beetles at the present time:

(1) Natural selection operating through a differential death rate, which should be distinguished as lethal selection, is here of minimum importance.

(2) Fecundal and sexual selection are also unimportant factors.

(3) Yet evolution is very active. It takes place through determinate variation and differential potency. The steps are largely mutative, but in other cases would seem to be flowing. The determinate variation, although fundamentally bathmic, is sometimes called out by environmental stimuli.

A Study of Selective and Environmental Factors.—E. N. Transeau.

During the absence of Dr. Shull I continued his experiments on the forms of *Bursa bursa-pastoris,* and studied critically several thousand plants, representing most of the families grown during the past year.

Of the 53 normal and abnormal plants of *Trillium grandiflorum* transplanted to the garden in the spring of 1906, 38 survive. Of the 15 plants which did not develop stem and leaves this year, 14 were of the abnormal type and included all of the extreme forms. The plants were somewhat reduced in size and all of the abnormal plants again failed to produce seed.

Considerable attention was paid to the leaf variations of *Rumex acetosella.* Forms having leaves with from 1 to 5 extra lobes were found in the vicinity of the laboratory and grown along with normal and lobeless forms. Guarded crosses were made among all of the forms and an abundance of seed secured. This plant was also used in a series of cultures to show the progressive effects of soil conditions on leaf size and form. Three very different soils were used and guarded seeds collected from each soil.

An attempt is being made to determine the chances of survival of single mutants of *Oenothera lamarckiana* growing in the midst of the parent species. About 2,000 seedlings, representing the progeny of the mutant and its neighboring plants, have been recorded.

Four species of *Lepidium,* represented by 2,672 plants, were grown for observation of variations and hybridization. All crosses thus far made failed to produce fertile seed.

Eight species of *Ipomœa,* represented by 200 plants, were grown in the garden. From these a large collection of self-fertilized seed has been obtained.

Work on the natural distribution of the vegetation about Cold Spring Harbor has been continued throughout the year. A report on this work will be made shortly. The transpiration conditions in most of the habitats have been studied by means of evaporimeters. Comparative results have been obtained by use of a standard instrument placed in the garden. This latter instrument was standardized to the evaporimeter of the Desert Botanical Laboratory, so that all of my readings are directly comparable with those at the latter station. The results indicate remarkable differences in the moisture conditions in the several habitats. A report on these evaporation records is in course of preparation.

Since coming to Charleston, Illinois, arrangements have been completed whereby greenhouse and garden space have been provided for the continuance of the breeding work with *Rumex* and *Ipomœa.*

RESIDENT STAFF.

The staff remains the same as last year, except that Prof. E. N. Transeau, who came to us from Alma College, Michigan, in July, 1906, has accepted a call to the Illinois State Normal School, Charleston, Illinois, as professor of botany. Dr. Transeau brought to the work the training of a plant physiologist and ecologist, a training that tended to broaden the work of the Station. Fortunately he will be able to continue as associate of the Station some of the investigations started here.

The vacancy made by the resignation of Dr. Transeau has been filled by the appointment of Dr. J. Arthur Harris as botanical investigator. Dr.

Harris has been for several years connected with the Missouri Botanical Gardens and the Shaw School of Botany, Washington University, St. Louis. He has published numerous papers, largely dealing with plant teratology and popular presentations of current evolutionary theory. It is believed that his precise knowledge of plant anatomy and teratology will be of valuable assistance in the experimental work of the Station.

During the month of October, 1907, Miss Lutz was spared from her work at the Station to assist Dr. C. S. Gager, at the New York Botanical Garden, in some cytological investigations on material with which he is working at the Station. This purely temporary arrangement has been made at the suggestion of the staff of the Garden to accommodate them and to add to Miss Lutz's experience.

CONSTRUCTION.

During the year three greenhouses, each 6 by 9 meters, connected with a frame laboratory 6 by 18 meters, have been completed. These were required for the plants used as food by insects or for plant pests devoured by insects (lady-birds, Coccinellidæ) whose strains are being maintained. One of the houses is used, during the winter, for the cultivation of lettuce and grasses required as food by the canaries and young poultry. An enlarged heating outfit was installed in this "vivarium" sufficient for all contemplated expansion of area under glass. A set of 15 hotbeds was constructed to provide for the overflow from the plant-propagating house. A shed 50 by 3 meters is being built around the stable to house certain of the live-stock during the winter and to store fodder, brooders, agricultural implements, and wagons used in hauling manure, soil, and supplies. To save the time of the poultryman the water system was extended to the brooder-house and the breeding-pens. To provide for investigators temporarily engaged at the Station one of the large rooms at the main laboratory was divided by partitions into three small rooms. The usual amount of fencing and cage-building was carried on. As a guide in planning for the construction and in laying out of the experimental gardens a survey was made of the main ground about the laboratory amounting to 8.2 acres, and this was plotted on a scale of 1 to 250.

EQUIPMENT.

In addition to the new vivaria, facilities have been increased by the addition of a few much-needed pieces of apparatus. As evolution involves fitness to conditions, we have needed to measure the various conditions of habitat. Two combined soil and air recording thermographs were purchased and are used, one in the garden and one in other habitats. A number of evaporimeters, of the type designed by Dr. B. E. Livingston, of the Department of Botanical Research, were secured and, as reported below by Dr. Transeau, were used in measuring the transpiration coefficient of parts of the experimental garden, the adjacent salt-marsh, woods, and hilltops. The data thus

secured will be used in cooperation with Dr. Livingston in a comparative study of the evaporation coefficients in different habitats and different parts of the country. The increased work with poultry made it necessary to purchase an additional incubator and four new brooders, thus bringing our total capacity at one time to 2,000 eggs in incubators and about 1,000 chicks in brooders. With this equipment it is possible to rear 3,000 chicks in a season. The new vivaria received each a complete outfit of hose, pots, and implements. At the beginning of the year a telephone was put into the administration office, connecting it with the outside world.

MAINTENANCE.

The residence, stable, and roof of the laboratory were painted, and the grounds and buildings kept in order as usual. Owing to excessive rains in the spring and violent electric storms in the autumn, our underground electric cables supplying light and power have not worked satisfactorily and we have been to some expense for repairs.

MINOR EVENTS IN THE DEPARTMENT.

In December, 1906, the meetings of convocation week were participated in by the staff of the Station, and a joint meeting of botanists and zoologists was held to discuss topics in evolution. At the same time a section on experimental evolution, under the chairmanship of the Director of this Department, was opened at the exhibition of the New York Academy of Science.

In February, 1907, most of the resident staff of the Station attended the meeting of the American Breeders' Association at Columbus, Ohio, and took an active part in its proceedings. The Director of this Department was elected secretary of the animal section of the association.

The Seventh International Zoological Congress held meetings in Boston in August, 1907. For the first time a section of heredity was organized. All but one of the members of the staff read papers in this section. On August 28 the Congress visited the Station at Cold Spring Harbor and the biological laboratory of the Brooklyn Institute of Arts and Sciences.

During the past summer the Station was used by Hofrath Professor Dr. Ludwig von Graf, Director of the Zoological Laboratory, University of Graz, and President-elect of the Eighth International Congress. We also received a visit from Mr. William Bateson, of Cambridge University, England, who gave a series of lectures on heredity at the Biological Laboratory and held conferences with members of the Station staff.

VIEWS OF THE GEOPHYSICAL LABORATORY, WASHINGTON, D. C.

GEOPHYSICAL LABORATORY,*

ARTHUR L. DAY, DIRECTOR.

NEW LABORATORY.

In December, 1905, at the annual meeting of the Trustees of the Carnegie Institution of Washington, the sum of $150,000 was appropriated for a geophysical laboratory. In the subsequent allotment by the Executive Committee, $100,000 was assigned to the purchase of a site and the erection of a building, and $50,000 to its equipment. It has proved practicable to provide for these within the sums allotted, in spite of the generally increasing cost of everything during the period intervening between the preparation of the estimates and the completion of the expenditures.

Site.—A site was purchased in the spring of 1906 upon a somewhat isolated hill in the northwest section of the city of Washington, only a short distance from the Bureau of Standards. The site itself includes 5 acres of land and is protected on three sides by the steep contour of the hill from the disturbing encroachments of future building operations. The land on the fourth side is permanently occupied by the Sisters of the Holy Cross, who expect to erect upon it several buildings for educational purposes. The tract is situated about 1,500 feet away from the nearest street-car line, and the geological formation is such that mechanical disturbances from without need not be feared. Reasonably convenient access to the site is now obtained by a temporary road through the adjacent property of the Sisters of the Holy Cross, but this must be abandoned in the near future on account of the extensive building operations contemplated by them. A permanent entrance-way would naturally be provided by the proposed continuation of Upton Street described in the street-plan adopted for the District of Columbia, which forms the southern boundary of the laboratory grounds. All the land required for continuing this street past our property, a distance of about 1,200 feet, has been dedicated to the District of Columbia without cost, and a formal request for the extension has been made. Its construction is now dependent upon favorable action by Congress.

Laboratory Building.—The design of the building was placed in the hands of Wood, Donn & Deming, architects, of this city, to be developed from tentative plans which had been prepared in the Laboratory and presented to the Executive Committee for examination the previous year (1905). Their problem was further complicated by great uncertainty in the cost of

* Situated in Washington, D. C. Grants Nos. 353 and 405. $190,000 for site, building, equipment, and investigations. (For previous reports on geophysical work see Year Book No. 3, p. 80; Year Book No. 4, pp. 224–230; and Year Book No. 5, pp. 177–185.)

all building materials and labor troubles in several of the building trades. The successful result is therefore an exceptional credit to them.

When ready, the plans were privately offered to eight building contractors for bids. The only bid which came within the appropriation was made by the firm of Richardson & Burgess, of Washington, to whom the contract was let, without essential modification, in June, 1906. Excavation was begun at once and construction continued without serious interruption throughout the winter, and the building was so far completed that we were allowed to move into it during the last few days of June, 1907. This enabled us to meet the desire of the Director of the Geological Survey that the space in the Survey building, which had been occupied temporarily by the Laboratory, should become free before July 1 of the current year.

The completed building is a substantial structure of attractive appearance, the architectural features of which are in the Spanish style, with wide overhanging roof.

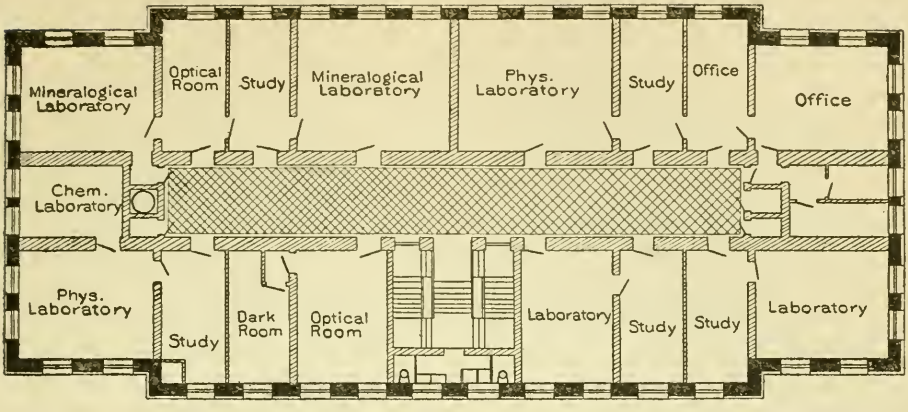
The character of the building and the floor-plan may be seen from plates 6 and 7. Its distinctive features require some further description. It comprises three floors and an unfinished attic, each floor containing about 6,400 square feet. The available floor-space is therefore about four times greater than the floor-space occupied in the Geological Survey, and affords not only necessary relief from the serious overcrowding which had been necessary there, but some desirable provision for the future of the undertaking. The rooms are grouped about a long central hallway on each floor, the hallway being left wide enough to accommodate instrument cases on both sides. The floors are of Portland cement throughout, covered in the working-rooms with German linoleum. The building is fireproof, except for the roof, even the tables and chemical hoods being almost entirely of stone, iron, or glass. Indirect steam heating with forced circulation of air is employed, the exhaust steam from the power plant being utilized to heat the entire building.

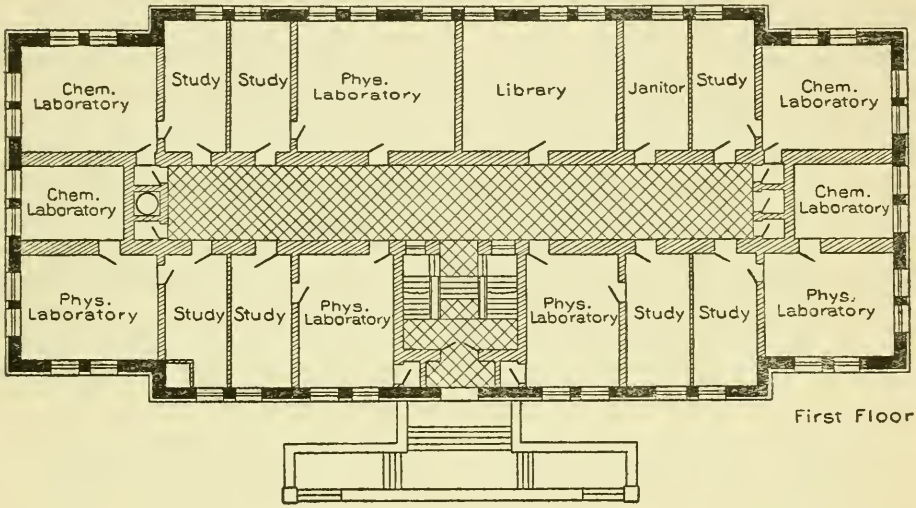
Special Features.—In preparing the plans of the laboratory, two problems of construction arose, each of which appeared to require special treatment at a minimum of expense. These were: (1) Such thermal insulation as would enable investigators to work without undue discomfort throughout a Washington summer, and (2) to provide against the disturbance resulting from the heavy machinery belonging to the plant itself without erecting a separate building for it.

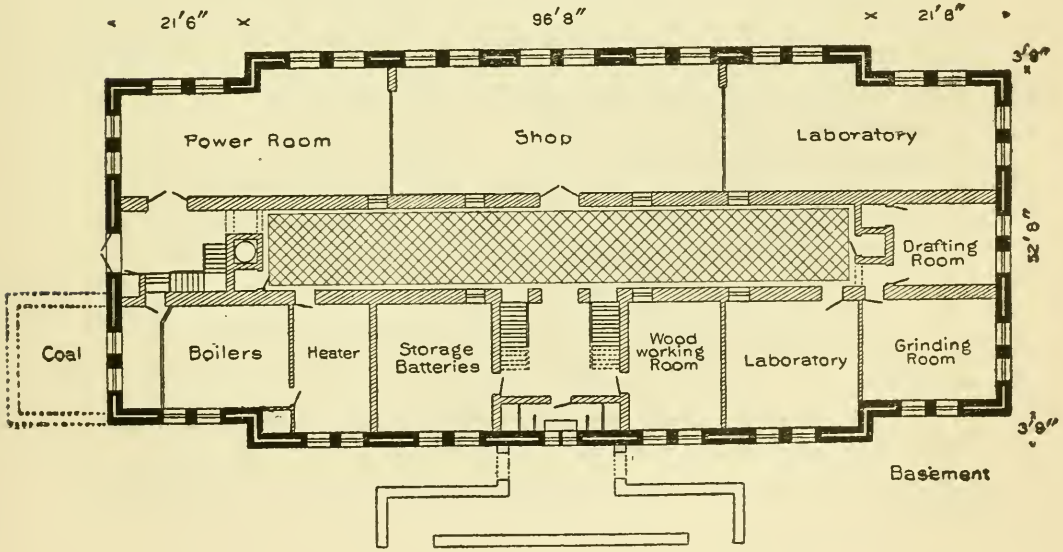
There are three common methods of meeting the first situation:

(1) By reducing the heat conductivity of the outside walls by building them double, with an air space between.

(2) By lining the walls with light non-conducting material, like magnesia brick.







FLOOR-PLANS OF GEOPHYSICAL LABORATORY.

(3) By providing refrigerating and drying plants of such a character that the air within the building shall be maintained approximately as cool and dry in summer as in winter.

The last plan has proved successful in several recent structures, but could not be considered in our case on account of the expense. The other two are not satisfactory and, so far as can be judged by the experience of others, are not worth the cost of installation. It was therefore thought wise to try a plan which, so far as we are aware, has not been tried before, namely, to place an insulating layer on the outside of the building. The exposed inner surface is then an ordinary brick wall of ample strength, from which the heat is kept away by an insulating layer of 6 inches of hollow terra-cotta, with the air-spaces laid horizontal and closed at the ends. So far as can be judged from the experience of the present summer, in which the heat has not been excessive, this has proved successful. Furthermore, such an insulating layer ought to help out the heating plant in winter, just as one is kept warm by an overcoat. This outside layer is less expensive than brick and structurally is almost as strong.

The problem of installing a considerable quantity of heavy machinery in the basement of a building without disturbing measuring apparatus of a high order of refinement upon the floors above is a serious matter, which has heretofore proved so nearly insurmountable that the usual practice is now to take it out of laboratory buildings entirely and provide for it in a separate building at a safe distance. This has two obvious disadvantages: (1) The cost of the additional building, and (2) the loss of power in transmission from the generating plant to the laboratory, which is considerable. There appeared to be one possible way out, which has been adopted, but the final result can not be communicated until we have had further opportunity to study the behavior of mounted apparatus. The experience upon which the scheme is based was gathered by Dr. G. F. Becker in a visit to several of the European laboratories and observatories, undertaken during the summer of 1903 and reported in the second Year Book of the Institution.

His observation was, briefly, this: Only two of the large laboratories and observatories of central Europe are satisfactorily free from mechanical disturbances—the Cryogenic Laboratory at Leyden, Holland, and the several observatories at Potsdam, Germany. The laboratory at Leyden is built upon piles driven in a foundation of mud and soft sand, while the Potsdam observatories are upon a sandhill which contains hardly a pebble of any size. In both these laboratories the mercury mirror could be satisfactorily used, and not elsewhere. From this observation it appeared that stability in the sense required by laboratories was not obtained by seeking a rock foundation, as has been the common practice. A modest and inexpensive attempt to apply this observation in our laboratory was made in this way: The basement floor of each room containing machinery consists of a block of Portland

cement 18 inches thick and completely separated, both at the bottom and sides, from the foundation walls of the building by a layer of 6 inches of dry sand, which, it is hoped, will prevent the vibration within the block from passing into the building. It is too early to offer conclusions upon the success or failure of this scheme, but preliminary runs with a 75-horsepower engine, which was not by any means in perfect adjustment, do not cause a noticeable disturbance on the floor above.

The remaining features of the laboratory contain little which is novel or of general interest. The main purpose has been to provide a number of independent laboratories, each adapted for a single research to be conducted by one investigator, with or without an assistant, and each laboratory is provided with a separate study immediately adjoining. Inasmuch as the laboratory is devoted exclusively to research problems, large general rooms, such as are commonly found in university laboratories, are conspicuously absent. At the same time, an attempt has been made to attain the maximum of elasticity in providing for future changes to meet the requirements of research which may not be foreseen at this time. Many of the subdividing walls of the building contain vertical flues of vitrified sewer pipe, through which communication may be had from one floor to another for gas, water, compressed air, or electrical transmission, or for carrying away fumes. Other walls are of very light construction, which could be removed to enlarge particular rooms or to redistribute laboratory space should occasion require. Elaborate permanent fixtures which, while convenient for one research, may be unnecessary in another have been avoided.

Equipment.—The equipment of the laboratory is a special and somewhat complicated problem, of which only the merest outline can properly be given here. In general, each individual laboratory is served with electric and other power according to its needs, the sources of supply being a direct-current generator of 62½ kilowatts capacity and alternating current from the city mains which can be used as such through transformers or rectified through mercury rectifiers, which have been found to work very successfully and economically. Where constant conditions are required, 5 large storage batteries (of 56 or 112 volts each) can be used separately, in parallel, or in series, as occasion may require. Any or all of these sources of supply may be furnished at one time to any laboratory room in capacity sufficient for all ordinary requirements. Facilities are also provided for compressed air at various pressures from 4,000 pounds downward, steam, illuminating gas, vacuum, etc., wherever needed. The optical work of the laboratory, which is required by all the investigations of a mineralogical character, is provided for in special dark-rooms with proper facilities.

Where both physical and chemical methods require to be applied upon the same problem, separate rooms are provided wherever possible in order that the chemical fumes may not cause deterioration in the instruments required

for the physical measurements. Inclosed hoods of stone and glass construction, practically airtight, and ventilated by forced draft, are provided for discharging dangerous fumes at the top of the building. The soapstone tables are covered, where a softer surface is necessary, with heavy linoleum, like the floor coverings.

Shop.—The equipment of the shop has been considerably extended in the new laboratory, and is now sufficient for making all repairs and much of the new special apparatus which is contemplated. This enlargement was made necessary in part by the removal of the laboratory to a point where it is less accessible to the machine-shops of the city, and partly by the fact that the apparatus used in the laboratory is of such a special character that it can only be competently handled under our own supervision. Power for the shop is supplied to each machine through individual electric motors. This enables us to dispense with shafting, which, if employed, would inevitably communicate troublesome vibrations to the building.

Provision for Research in Elasticity and Plasticity.—The removal of the high-temperature laboratory from the Geological Survey building so far reduced the need for laboratory facilities there that it seemed to the Director of the Survey unwise to attempt to continue physical work with the limited equipment remaining. It was therefore decided to transfer the work on elasticity and plasticity, which is jointly supported by the Geological Survey and by the Carnegie Institution of Washington, in charge of Dr. George F. Becker, to the new laboratory building, where it would have the benefit of the largely increased facilities now available.

Grounds and Outside Connections.—A special appropriation of $4,000 made by the Executive Committee at its meeting of May 11, 1907, for fencing, grading, and improving the laboratory site, building a proper roadway, and bringing in water and gas connections from Upton street to the laboratory has been nearly all expended for these purposes. The laboratory is now provided with all the usual city connections—sewer, water, electricity, gas, and telephone—with satisfactory service in each department.

SCIENTIFIC WORK.

As was to be expected, the laboratory work of the year has suffered considerably from interruptions incidental to the transfer of the apparatus to the new laboratory building and remounting it under the new conditions. This amounted in many cases to the complete dismantling of complicated systems, where some months will be required to provide all the connections necessary for their operation and to restore them to perfect adjustment. It was therefore thought wise to confine our activities much more strictly than usual to preliminary and incidental researches rather than to attempt work in which the results must suffer from the disturbed conditions of experiment. By incidental researches is meant the devising and testing of methods, the

control of errors, and the quantitative determination of those constant factors which enter into the problems through the changed laboratory conditions. Some of this work is of sufficiently general interest to warrant publication, but more of it is entirely preliminary and will apply in its proper place in the work of the coming winter.

Calorimetry.—One of the more interesting examples of this preliminary work, which has not been mentioned before in the reports from this Department, is the preparation, now well advanced, for the exact study of the heat involved in mineral formation and inversion and the specific heat of the stable forms. As a physical problem, this is an attempt to apply calorimetrical methods at the temperatures of mineral and rock formation (1,000° to 1,500° C.), a region so remote from the usual domain of calorimetry that a very careful scrutiny and some modification of existing methods was inevitable. In fact, the question has been found so serious that the successful solution of it has occupied one observer throughout the entire year.

The phenomena heretofore investigated in the Laboratory have depended primarily upon the establishment of the temperature which is characteristic of certain reactions. It therefore constitutes a most important extension of the scope of our observations to attempt to determine, in addition to the temperature of a given reaction, also the quantity of heat which is involved in it. To students of physics and chemistry the importance of obtaining this additional information in the study of any group of substances will be immediately obvious. Nor have mineralogists and geologists been unappreciative of the need of measurements of this character;* but in the absence of all data, or of a physical laboratory devoted to problems of geological interest, they have often found it necessary, for the proper discussion of field observations, to formulate working hypotheses involving definite quantities of heat without any basis of experimental fact whatever. The contact relations between wall rock and an intruding magma is a case in point.

A preliminary report upon this calorimetric installation was prepared and presented to the American Physical Society at its spring meeting in Washington, and reported in abstract in its Journal.† A brief résumé of the principal conclusions is included in the list of publications following (p. 94).

Temperature Scale.—In much the same way the work upon the fundamental scale of temperatures, to which reference was made in the last annual report, has passed through an important preliminary stage during the present year and was reported briefly at the spring meeting of the National Academy of Sciences and at the meeting of the Physical Society‡ a few days later. Except for the expansion coefficient of the thermometer bulb, which requires

* See report of President Van Hise upon the reasons for establishing a geophysical laboratory, in Year Book No. 2.

† Phys. Rev., August, 1906, p. 137.

‡ Abstract in Phys. Rev., June, 1906, p. 531.

to be redetermined with considerable accuracy, the work upon the high-temperature gas scale up to 1,200° is finished and the accuracy of the determination very satisfactory. After remounting the apparatus, which is very complicated, this investigation will be continued in the new laboratory to temperatures considerably higher than 1,200°, and, if successful, as there is now considerable reason to believe it will be, will contribute greatly to the exactness of all temperature measurements in that, for mineral formation, most important region lying between 1,200° and 1,600° C.

Action of Water upon the Minerals.—Another investigation, which was foreshadowed in the last annual report from the Geophysical Laboratory, is the action of water upon mineral and rock formation, to which the geologists attach the utmost importance and upon which experimental measurements are still almost entirely lacking. Preliminary work in this direction has been undertaken in closed bombs within which great pressure can be developed, using several different mineral combinations and with considerable variations of the physical conditions, pressure, and temperature. But it is hardly fair to offer even a preliminary report upon such a complicated subject with the data so far at our disposal. The experiments are difficult, require much time and labor, both in preparation and in execution, and the experimenter is frequently led far afield by the complete absence of any trustworthy experience in such work. One conclusion of importance appears to follow from our experimentation so far, namely, that the activity of hot water under high pressure as a "mineralizing" agent has been very greatly overestimated, unless—and here lies the key to the apparent activity of water in nature which geologists and mineralogists have uniformly recorded—the water contains substances, like the soluble alkaline salts, in solution. Its activity in contact with the more stable minerals is then enormously increased. It may be fairly inferred that the waters of nature, the chemical activity of which is very apparent in many formations, were charged to a high degree with these soluble salts. The problem as it now stands, after these preliminary trials, is much more complicated than has heretofore been suspected, and is therefore one step farther removed from prompt and final solution.

Mineral Solutions.—Our established lines of investigation in mineral solutions have been continued during so much of the year as the Laboratory remained undisturbed in its old quarters, but the equipment of the new building is not yet sufficiently advanced to enable us to resume it. The more recent work has been confined to studies of the alumina-silica series, including sillimanite in its various physical forms, the metasilicates of calcium and magnesium in which diopside occurs and which is now nearly complete and ready for publication, and, finally, some more or less preliminary work in adjacent portions of the lime-magnesia-silica 3-component system, in which an investigation of tremolite is perhaps the most important and farthest advanced.

Mixtures of alumina and silica have proved unusually difficult to study, on account of the extremely high temperatures at which combination takes place, which carries them out of reach of the more convenient forms of electric furnace and makes the accumulation of definite experimental data more difficult and much slower. Inasmuch as a recent paper from this Laboratory on the "Lime-silica series of minerals"* appeared to upset one of the fundamental assumptions heretofore made regarding the composition of Portland cement, it is hoped that this investigation of alumina and silica may mark the beginning of the acquisition of some positive information upon the character of this most important and useful mineral combination.

The study of wollastonite and the analogous silicate of magnesia has not only yielded important information regarding the conditions under which these minerals combine, but appears to contain a most interesting example (the first among the minerals) of a eutectic and a solid solution in the same series, probably corresponding to Type V of Roozeboom's theoretical treatment of the 2-component series. Diopside is definitely established in its familiar position as a 1 : 1 combination of the metasilicates, which combines with wollastonite in the typical eutectic relation and with magnesium metasilicate in a more complicated fashion, which is not yet entirely established. This is not especially surprising in view of the fact that the study of magnesium metasilicate published a year ago† showed this composition to be capable of existence in four forms in monotropic relation to each other, of which enstatite, the most common mineral of this composition, is not the most stable. It is therefore extremely difficult, in combinations of diopside and magnesium metasilicate, to be quite sure of the degree of stability obtaining in a particular mixture, within the limited time required for a laboratory experiment.

Published Work.—The published work of the Laboratory during the year 1907 has appeared in the scientific journals under the titles indicated below:

(1) Bemerkungen über die Julius'sche Galvanometeraufhängung. Walter P. White. Ann. d. Phys. (Leipzig), (4), 22, pp. 195–198, 1907.

A description of a number of proposed modifications of the Julius suspension, a device for mounting galvanometers or other physical apparatus in such a way that it will not be disturbed by vibrations in the building.

(2) Die Konstanz der Thermoelemente. Walter P. White. Phys. Zeitschr. (Göttingen), 8, pp. 325–338, 1907.

Reprinted in German from "The constancy of thermoelements" (Physical Review, 23, pp. 449–474, 1906) at the special request of the editor of the Physikalische Zeitschrift. In this republication some new matter was added embodying later information upon the same subject. Through increased refinement in the methods of testing the elements, some further disturbing

* Amer. Journ. Sci., October, 1906, p. 265.
† Amer. Journ. Sci., November, 1906, p. 385.

irregularities were discovered, small in amount and as yet unexplained, but apparently pointing to contamination of a different kind from that due to iridium, which forms the chief source of error in the use of thermoelements in platinum furnaces in an oxidizing atmosphere.

(3) Thermokraftfreie Kompensationsapparate mit Kleinem Widerstand und Konstanter Galvanometerempfindlichkeit. Walter P. White. Zeitschr. f. Instr. (Berlin), 27, pp. 210–219, 1907.

Constant galvanometer sensibility can be attained for a wide range of electromotive forces with considerable ease by a suitably constructed potentiometer, and when attained contributes greatly to the facility and rapidity with which measurements of current and electromotive force are made. Such a potentiometer is described in this article. The results are secured by the use of compensating coils and, in instruments of especially great range, of shunted resistances, a device which has already come into use in other kinds of electrical measurements. The potentiometer described, besides giving constant galvanometer sensibility, is less liable to certain other errors than any of the other types of equal range. It is not more difficult to build or appreciably more complicated than the well-known standard instruments.

(4) Some new measurements with the gas-thermometer (abstract). J. K. Clement. Phys. Rev., 24, p. 531, 1907.

A new gas-thermometer has been designed and built in the Geophysical Laboratory, for the measurement of high temperatures, in which a conscientious effort has been made to reduce the magnitude of the errors common to the well-known European gas-thermometers. The constant-volume principle and the thermoelement as the medium of comparison are retained, but the sensibility of the instrument has been increased until the error of an individual reading is no greater than the error in the corresponding barometer reading. The bulb (10 per cent iridium, 90 per cent platinum, 200 c. c. capacity) is suspended in an air-tight bomb, by means of which the pressure outside of the bulb is maintained nearly equal to the inside pressure. This makes it possible to use a high initial pressure—about 300 mm. Hg.—without deforming the bulb at high temperatures, and thus to obtain a sensibility of about 1 mm. of the manometer scale per degree centigrade without diminishing the range of the instrument.

By taking advantage of the fact that the increased viscosity of the expanding medium (nitrogen) due to rise in temperature affects only the heated portion of the dead space connecting the bulb with the manometer, it has been found possible to reduce the diameter of the cold portion of the capillary connecting-tube to 0.5 mm., so that the ratio of the volume of unheated space to the volume of the bulb, $v_s/V = 0.0015$. (Holborn & Day, $v_s/V = 0.0046$; Jacquerod & Perrot, $v_s/V = 0.0180$.) The entire correction for the unheated space is therefore only 3.8° at 1,000° and 5° at 1,200°.

Perhaps the most important source of error which has been overcome is the variation of temperature along the bulb itself, due to the cooling at the ends of the furnace tube. By the use of auxiliary heating-coils at either end of the main coil, the gradient between the center of the bulb and either end of it has been made less than 0.5°.

We have made a number of comparisons between this instrument and Pt-PtRh thermocouples from 300° to 1,200° at intervals of 25°, in which the aggregate error from all sources appears to be well within 1°. There has not yet been an opportunity to make a complete series of melting-point

determinations, but the following are offered tentatively, subject to a redetermination of the expansion coefficient of the bulb. The coefficient of expansion used for the computation of these values is that of Holborn & Day ("On the gas-thermometer at high temperatures," Amer. Journ. Sci., 4, 57, p. 171, 1900).

Melting-point Determinations.

Metal.	Melting-point.	Greatest deviation from mean.	Number of determinations.
	°	°	
Zinc	418 4	± 0.4	15
Silver	957.5	....	1
Gold	1059.1	....	1
Copper	1080.2	± 0.5	5

(5) An accurate calorimeter (abstract). Walter P. White. Phys. Rev., 25, p. 137, 1907.

This calorimeter is used in connection with an electric resistance furnace. It is therefore completely inclosed with a double-walled jacket, through which water is kept circulating. As the amount of manipulation necessitates the maximum simplicity in methods of measurement, the temperature is determined by a thermoelement, which can be read on a potentiometer almost at the same time with the temperature of the furnace, the differential temperature of the calorimeter and jacket, and the voltage and current used in calibration. The temperatures can be read concordantly to about 0.001°. The use of large calorimeters and small temperature intervals has been recommended in order to reduce cooling corrections, but at best a small gain in cooling correction, when secured in this way, requires a very large increase in the sensitiveness of the thermometer, while, in so far as the cooling errors come from the difficulty of *determining* the cooling correction or from the heat generated in stirring, they are actually greater in the large calorimeter. Hence the temperature interval of 20° was chosen.

Further reasons for a small temperature interval and large calorimeter are found in the closer approximation to Newton's law of cooling and in the reduced effect of the metal parts of the calorimeter. With the present arrangement of jacket and floating cover (to diminish evaporation), however, practically everything within the case is at one of two temperatures—that of the calorimeter water and that of the jacket water—whose difference is actually measured. Uncertain and lagging temperatures of the metal parts are thus practically eliminated. The slight variation from Newton's law is easily determined and applied as a correction, since the difference in temperature between the calorimeter and its *whole* environment can be at all times exactly shown.

Experience has shown that the regularity of the cooling is at least equal to the maximum accuracy obtained in measuring it. The principal errors thus far observed have been clearly traceable to lack of sensitiveness in temperature measurement. The selection of a wide temperature interval, therefore, seems completely justified.

The calorimeter resembles in plan a figure 8 with a propeller in one side. Dead spaces are completely avoided.

Calibrations by the electrical method are still in progress. Seven preliminary results with inferior sensitiveness have already shown an average variation of only 2 parts in 10,000.

(6) Die Kalkkieselreihe der Minerale. Arthur L. Day, E. T. Allen, E. S. Shepherd, Walter P. White, Fred Eugene Wright. Min. Petr. Mitt. (Vienna), *26*, pp. 169–232, 1907.

A translation into German, with some additions, of the papers "On wollastonite and pseudo-wollastonite, polymorphic forms of calcium metasilicate" and "The lime silica series of minerals," reviewed in the last annual report.

(7) Measurement of the optic axial angle of minerals in the thin section. Fred Eugene Wright. Amer. Journ. Sci., (4) 24, pp. 317–369, 1907.

The questions involved in the general problems of rock formation require for their solution definite data on the conditions of formation and the properties of rock-making minerals. To furnish accurate and reliable data of this sort it has been found necessary to determine the relative accuracy of the methods available for the determination of the different constants, both physical and chemical, of these minerals. In this paper the various methods for the measurement of the optic axial angle of minerals under the microscope are considered in detail and their relative accuracy tested under different conditions. The optic axial angle is one of the most characteristic constants of biaxial minerals, and is used frequently in practical microscopic mineral diagnosis.

In convergent polarized light, methods for the measurement of the optic axial angle are available for all sections in which at least one optic axis appears within the field of vision. Of these, the method requiring the use of the Becke drawing-table is of general application and furnishes results of a fair degree of accuracy, the usual probable errors being about $\pm 1°$ if both optic axes are visible, and $\pm 5°$ if only one optic axis is visible. More accurate and somewhat simpler in manipulation and of the same general application is the method involving the use of a new double-screw micrometer ocular, described for the first time in this paper. This ocular, combined with the method of projection of Professor Wulff, is a general extension of the Mallard method, and, like the Becke method, utilizes the rule of Biot & Fresnel defining the planes of vibration for any particular direction of wave propagation. With this ocular the probable errors of determination should not exceed $1°$ if both optic axes are visible, or $3°$ if only one optic axis appears in the field. The Mallard method and formula, which underlie these methods, have been tested, and the agreement of formula with fact for the special objective used found to be remarkable.

In parallel polarized light the methods involving the Fedorow-Fuess universal stage furnish satisfactory results, providing the position of one optic axis can be determined directly. In case both optic axes are outside the field of vision, the values obtained are usually unsatisfactory and inaccurate. If both optic axes appear within the field of vision, the error of determination by means of the universal stage should not exceed $1°$, and if only one of the optic axes is visible the accuracy decreases to $\pm 5°$.

The methods based solely on extinction angles for different faces are inaccurate and unsatisfactory, chiefly because of the undue influence of small differences in extinction angle on the resulting optic axial angle.

In addition to the double-screw micrometer ocular, several new appliances are described—an improvement of the Fedorow-Fuess universal stage, a new form of condensor lens system, and a disk-shaped type of the Becke drawing-table.

(8) Potentiometer installation, especially for high-temperature and thermoelement work. Walter P. White. Phys. Rev., 25, pp. 334–352, 1907.

A fairly complete description of the methods of making the electrical measurements of temperature regularly in use in the laboratory up to 1,600°, with a discussion of the character and magnitude of the errors involved, the treatment of leakage, etc.

DEPARTMENT OF HISTORICAL RESEARCH,*

J. FRANKLIN JAMESON, DIRECTOR.

The following report covers the period from November 1, 1906, to October 31, 1907.

Those general thoughts on policy which underlie the work of the Department were stated with some fulness in the last annual report. It is not needful to do more in the present report than to recall the leading features of the policy therein advocated. Its chief principles were, that a department of historical research in an endowed institution should leave to individual historical scholars the preparation of monographs and general histories, and that it should aid them to as large an extent as possible by the more primary work of locating and describing important original materials, and by the printing of the chief of them; that accordingly its publications should consist of two classes—on the one hand a series of reports, aids, and guides, reporting on materials on American history in archives domestic and foreign, or otherwise mediating between the worker and his sources of knowledge, and on the other hand textual publications of documents; that in dealing with archives or other large collections of material the first stage should be the preparation of comprehensive surveys, to be followed later by calendaring or printing of what is most valuable; that all this should be planned and conducted with constant regard to the scope and work of other historical agencies, with avoidance of duplication, with help and cooperation whenever practicable; and that meanwhile individual inquirers engaged in work having real scientific worth should be aided in such ways as the advantageous position of the Department in Washington would make possible.

WORK FOR THE PAST YEAR.

Reports, Aids, and Guides.—In the winter and spring Mr. Leland, with assistance from Mr. J. H. Russell and Dr. C. H. Lincoln, completed the manuscript of the revised edition of the first publication of the Department, Van Tyne & Leland's "Guide to the archives of the Government of the United States in Washington." This involved prolonged examination of many portions of the scattered government archives which had not been explored previously, and the preparation of descriptions so much fuller that the new volume will be about two-thirds larger than the original issue. In particular, the statements regarding the historical material in the Bureau of Indexes and Archives in the Department of State, in the Archives of the Post-Office and Navy Departments, and in the Library of Congress, are much more ample. The volume is now in the press.

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* Address: Bond Building, Washington, D. C. Grant No. 402. $18,700 for investigations and maintenance. (For previous reports see Year Book No. 3, pp. 65–79; Year Book No. 4, pp. 232–237; and Year Book No. 5, pp. 186–201.)

Prof. W. H. Allison has continued the collection of data for his report on the materials for American religious history preserved in denominational archives and the libraries of colleges, theological seminaries, and missionary societies, by examining during the summer a considerable number of ecclesiastical archives of this sort, situated at Dayton, Ohio; Philadelphia, Germantown, Mount Airy, and Haverford, Pennsylvania; New York City; Boston, Medford, and Andover, Massachusetts; Hanover, New Hampshire; and Lewiston, Maine. This, added to the work of the last year, nearly completes the list of such repositories which contain enough material to justify personal visitation, or are so placed as to make it practicable without large expense. Archives less rich, or situated in more remote sections of the South and West, have been addressed by circular. In most cases those having any considerable amount of valuable material have supplied the necessary data. With a few exceptions, therefore, the work of collection is completed, and the data have been taken down in such a form as will make it easy to put the whole in shape for publication.

After some typographical experiments, intended to secure the best form for reports on foreign archives, Mr. Luis M. Pérez's "Guide to the materials for American history in Cuban archives" has been issued in an octavo volume of 152 pages. Besides the aid it has already rendered to several historical investigators, its publication has had an excellent effect in drawing public attention in Cuba to the value of the national archives, and in leading the provisional government to bestow much more care upon this interesting national possession than previous governments have done. On the ground of military necessity during the insurrection of August, 1906, the preceding government had caused the national archives to be moved, in great haste and disorder, from the Cuartel de la Fuerza to even more unsuitable quarters. Much loss and confusion was caused by the removal. The provisional government has taken measures to remedy this disaster, as far as posible, has caused the present archive building to be adequately shelved, has begun the preparation of a card index, and has introduced better regulations as to the copying and historical use of papers.

Prof. W. R. Shepherd's "Guide to the materials for the history of the United States in Spanish archives (Simancas, the Archivo Historico-Nacional, and Seville)," an octavo of about 105 pages, will be issued within a few days of the completion of the year herein reported on.

Prof. C. M. Andrews's "Guide to the materials for the history of the United States to 1783 in London archives, in the British Museum, and in the manuscript collections of Oxford and Cambridge," now completed, would make in print two octavo volumes of about 400 pages each. When arrangements for its printing had been concluded, and the first volume was mostly in the printer's hands (only a few pages, however, having been actually set up in type), word was received from Professor Andrews in London which compelled all progress with this volume to stop. The British Public Record

Office had taken a resolution, which there had been no means of foreseeing, to effect a total rearrangement of that section called the "Colonial Office Papers," naturally the section of chief importance to American history, and constituting, with some other sections which are also to be rearranged, much the largest part of the subject-matter of Professor Andrews's first volume. The reorganization is to be so thoroughgoing that most of the volume will have to be rewritten, and it will last so long that the rewriting can not be undertaken till the summer of 1909.

These conditions seem to force a change of plan. According to the original design, volume I was to consist of the material relating to the Public Record Office as the chief national archive, while volume II was to deal with the British Museum, the lesser public archives of London, and the materials in the libraries of Oxford and Cambridge. Nothing impedes the printing of this volume. But it is awkward and undesirable to bring out, as volume II of a work, a book which is to be followed only after several years by volume I. Therefore it is proposed, leaving perforce in manuscript the Public Record Office volume, to issue at once a volume bearing the separate title of "Guide to the materials for the history of the United States (to 1783) in the British Museum, in minor London archives, and in the manuscript Collections of Oxford and Cambridge."

This volume will consist primarily of the data collected by Professor Andrews at the British Museum and at the Privy Council Office. Next will follow Miss Frances G. Davenport's notes from the archives of the House of Lords, of the General Post-Office, of Trinity House, of the London Guildhall, of the Middlesex Sessions, of the Old Bailey, of the province of Canterbury (Lambeth Palace), of the diocese of London (Fulham Palace), of the Society for the Promotion of Christian Knowledge, of the Society for the Propagation of the Gospel, of Dr. Bray's Associates, of Sion College, of the Catholic province of Westminster, in Dr. Williams's library, at the Congregational Hall, at Devonshire House (Society of Friends), in the archives of the Royal Society, and in those of the Hudson's Bay Company. Lastly will follow Professor Andrews's notes on the American papers in the Bodleian Library and in the libraries of the colleges of Oxford and Cambridge. This volume is now ready for the press. As it would in any case have a separate index from that of the Public Record Office volume, there is no necessity for uniting the two in publication.

For similar explorations of French and Mexican archives, Mr. Waldo G. Leland, a member of the regular staff of this Department, sailed for Paris at the end of June, while Prof. Herbert E. Bolton, of the University of Texas, proceeded to the City of Mexico. Mr. Leland's searches are to be limited to Paris. Mr. Bolton is expected, after completing his notes upon the materials for the history of the United States in the archives of the Federal capital, with which he is already familiar, to visit those provincial repositories, civil and ecclesiastical, in which such papers may be expected to be found. These

are chiefly in towns in northern Mexico, former capitals or sees, on which portions of the present area of the United States once depended, either in civil or in religious administration. The missions of both gentlemen have been favored by the kind offices of the Secretary of State and of our diplomatic representatives in the respective countries; that of Mr. Leland also by those of His Excellency the French Ambassador in Washington; that of Mr. Bolton by those of His Eminence Cardinal Gibbons and His Excellency the Apostolic Delegate in Washington. In the spring, as a portion of his preparation for his mission, Mr. Leland visited the Canadian Archives at Ottawa, whose work has for many years had close relations with certain Parisian archives, and in which he received valuable aid and suggestions from the distinguished archivist, Dr. Arthur G. Doughty.

On his way to the City of Mexico Professor Bolton made brief preliminary visits to archives in Matamoros, Reynosa, Camargo, and Querétaro. At the Federal city he has examined in the Archivo General about 5,000 volumes of manuscripts and taken adequate notes on those that contain material for the history of the United States. He has also examined all the pertinent material in the Museo Nacional, and has made a beginning at the War Department. Mr. Leland's work since he arrived in Paris has been in the Bibliothèque Nationale, and in the archives of the Ministry of Foreign Affairs. Both gentlemen send monthly reports of progress to the director of the Department.

The listing of transcripts of documents in foreign archives, which can be consulted in the United States, has made little progress during the year, chiefly owing to the absence of Mr. Leland and his preparations for his present expedition. Those from Cuban archives are mentioned in print in Mr. Pérez's Guide. Though little remained to be done in order to complete the list of those from Spanish archives, originally intended to accompany Mr. Shepherd's volume, it was not deemed best to delay its publication by waiting for this supplementary material.

Although the trustees of the Carnegie Institution of Washington deemed it inexpedient to continue, by authorizing subsequent annual issues, the volume entitled "Writings on American history, 1903," prepared under the directorship of Professor McLaughlin, it was agreed that the present Director might take the needful time to secure, if possible, by other means the continuance of this useful bibliographical instrument. With a great deal of labor and difficulty, he has succeeded in organizing a group of historical societies and of interested individuals, who guarantee for five years a sum sufficient, it is believed, to maintain the enterprise. The lapse of time makes it requisite to leave the product of the years 1904 and 1905 uncatalogued for the present. A volume for 1906 is now in active preparation.

Textual Publication of Documents.—The collection of letters of delegates to the Old Congress has been advanced by the search, nearly completed, for

manuscript materials of this sort accessible in Washington. But it has been thought essential, at this stage of the preparation of that work, to list with proper care all those letters of the class included in our scheme, which have already been printed. Whether these shall or shall not be printed in conjunction with the others is a matter for subsequent determination, depending among other things upon quantitative considerations; but at any rate we should have a full list of them in hand. The printed material for the period 1774–1789 is so voluminous that this search has involved much labor, occupying a large part of the time, since he joined our staff in January, of Dr. E. C. Burnett, to whom the editorial care of this series has been assigned. This search is now nearly completed.

Miss Davenport's time since she returned from London has been so largely occupied with preparing for publication in the Guide, mentioned in the previous section, her notes on the minor archives of that city, that she has been able to do little with the collection of treaties between foreign powers which have a bearing on American history.

The proposed edition of the proceedings and debates of Parliament respecting the American colonies has advanced by several months' substantial work on the part of Dr. H. M. Bowman, who was chiefly engaged with this series until he left our service to enter that of the archives of the Dominion of Canada. Work on the proceedings logically preceded work on the debates, for the former would inevitably show a greater number and range of items than the latter, since many votes or actions of Parliament are not represented by any recorded debates. At the time of his departure, Dr. Bowman had nearly completed to 1783 a list of all the entries relating to America in the Commons journals.

Several other enterprises of textual publication for the colonial period, alluded to in last year's report as possible and desirable, are in a fair way to be completed by other means. At the instance of the clerk of the Privy Council and of the professor of colonial history in the University of Oxford, the Lords Commissioners of the Treasury have agreed to print at government expense, to the extent of three royal octavo volumes, a collection of those entries in the registers of the Privy Council which relate to the British colonies before 1776, provided the expense of copying and editing is otherwise defrayed. I earnestly hope that the Carnegie Institution may bear a part in the maintenance of this series, sure to be rich in new and important materials for our history, since the Privy Council was, throughout the period indicated, the central organ of British colonial administration, yet few historians have hitherto had access to its records. A second enterprise, the publication of the royal proclamations respecting America, has been undertaken by the American Antiquarian Society, while one embracing all acts of Parliament relating to the colonies before the Revolution has been taken in hand by Professor MacDonald, of Brown University. To the second of these undertakings this Department has rendered considerable aid.

Miscellaneous Operations.—As heretofore, the editing of the "American Historical Review" has been carried on in the office of the Department and by its staff. Mr. Leland has prepared the annual summary of American historical progress, appearing in the "Jahresberichte der Geschichtswissenschaft." The endeavor has been made to file methodically such data regarding manuscript materials for American history, preserved in Washington or elsewhere, as have come to hand. Historical societies have been aided in the quest for historical materials in Washington. Mention may be made of the American Antiquarian Society, in the instance named above, of the Michigan Pioneer and Historical Society, which continues its copying of papers of Henry R. Schoolcraft; of the Buffalo Historical Society, which has been helped in its endeavors to prepare an edition of the writings and correspondence of President Millard Fillmore, and of the State Historical Society of Wisconsin, and others, in minor searches. Mr. Leland is also under instruction to meet, so far as is practicable, the desires of certain historical societies for information from the archives of Paris relating to their respective States.

A considerable amount of the time of the staff is consumed in hunting in Washington libraries and archives for the answers to questions sent in by individuals. The number of such must, in the course of the year, have amounted to some figure between 100 and 200. But the work is a legitimate part of our duty and not the least important. Discrimination must of course be exercised, and little time can rightly be spent in answering questions which have no one's benefit in view but that of the writer, or have no historical importance. But, as the notion of establishing a clearing-house for the historical profession had certainly its part in the locating of this Department in Washington, and as our fortunate relations to its archives and libraries, particularly to the ever-helpful Library of Congress, enable our staff to increase the efficiency of remote historical workers who are aiming to advance our science, it is proper and pleasant for us to spend some of our time in assisting them. The Department itself is under frequent obligations to these same historical scholars or to others at a distance.

Under an appropriation for small grants to scholars who need to visit Washington for historical research, such aid has been rendered to three persons: Dean W. H. Isely, of Fairmount College, in Kansas, engaged in researches into the history of the civil troubles in Kansas in the period before the Civil War; Prof. J. C. Ballagh, of the Johns Hopkins University, engaged in collecting materials for an edition of the correspondence of Richard Henry Lee, and Prof. I. J. Cox, of the University of Cincinnati, engaged in studying the history of the southwestern boundary of the United States. They are experienced historical workers and their subjects are important.

PLANS FOR 1908.

Reports, Aids, and Guides.—The volume described in a previous section, prepared by Professor Andrews, with the assistance of Miss Davenport, and entitled "Guide to the materials for the history of the United States (to 1783) in the British Museum, in minor London archives, and in the manuscript collections of Oxford and Cambridge," can easily be brought out early in 1908. Professor Allison's inventory of materials for American religious history preserved in ecclesiastical archives will with little doubt be ready in the spring. It is hoped that Dr. Marcus W. Jernegan, formerly of the University of Chicago, who will take Mr. Leland's place while the latter works in Paris, will be able, along with other labors, to make at least an important beginning of the proposed calendar of papers, scattered through various archives in Washington, relating to the history of the territories of the United States. Such a list, as was explained in my last report, will be of great use to all who are working on the early history of our Western States, yet is certain not to be prepared by any one Department of the Federal Government. It will also be possible to complete for publication our list of transcripts and printed documents from the Spanish archives, with the possible exception of those in the H. H. Bancroft Library, lately acquired by the University of California, and to publish this list as an accompaniment to Mr. Shepherd's Guide.

In Mexico Mr. Bolton, whose leave of absence from the University of Texas will expire in September, will from present appearances complete, early in 1908, his inventory of the papers relating to the history of the United States contained in the civil and ecclesiastical archives of the Federal capital, after which he will carry through, as far as is possible, a similar examination of the various provincial archives in the northern States of the Republic. If the time proves insufficient for examining all these with the same care he has applied in the City of Mexico, he will naturally devote himself primarily to those which are farthest from Texas, leaving some of those nearest to be dealt with subsequently during some briefer leave of absence or vacation. After his return to Austin in September he will give his time, so far as university duties allow, to preparing his report from the notes accumulated. To a large degree, however, he is already doing this, day by day, during the hours in which archives are not open. Similarly, Mr. Leland will expect to complete by the end of September his survey of the Parisian archives, and then to return to America with the materials for a volume.

In the summer, before these researches are quite completed, I desire to have a beginning made of a year's work in the archives and libraries of Rome, where, as explained in the last annual report, a rich harvest of material for American history awaits investigation, for which, it is believed, ample facilities have been secured by various official permissions.

Texts.—After the completion of the London Guide, now to be published, Miss Davenport will, as far as is possible, devote her time entirely to the finishing of her collection of treaties between foreign powers having a bearing on the history of the United States. It is desirable that the scope and purpose of this volume should be more fully explained than has hitherto been done. It is proposed to include all international treaties and conventions which have a direct bearing on the history of the United States or of any region now a part of the United States, exclusive of those to which the United States was a party. Certain early papal bulls, having in international law an authority similar to that of treaties, and a few capitulations resembling treaties in importance (*e. g.*, Montreal, 1760; Pensacola, 1780) will also be included. The definition given above, it will be seen, embraces not only the treaties negotiated by European powers, but those made by the Republic of Texas and independent Hawaii. It includes *asiento* treaties, though their bearing is rather on the economic and social than on the political history of the United States, and perhaps, for the same reason, certain other treaties respecting the slave trade. It is not intended, however, to print whole treaties in cases in which only a part has relation to American history, but, in such instances, to print only the relevant portions. Proper historical introductions and annotations will be supplied by the compiler.

The bearing of such a series of texts on the study and teaching of American history is plain. Aside from that obvious value, there are several reasons for making up such a collection. The main reason is that most of these treaties can not be consulted except in very expensive general collections of treaties, which only a few libraries possess. Two of those discovered by Miss Davenport in London have never been printed, either in the original or in English translation; of several interesting German treaties the original has never been printed. Moreover, the printed texts can seldom be relied on as accurate and complete. The texts in our collection are nearly ready for the printer; the remaining work is mainly that of preparing introductions and notes.

The series of Letters from Delegates to the Old Congress is intended to supplement the "Journals of the Continental Congress" by printing those letters or parts of letters, and only those, in which members of the Congress convey contemporary or nearly contemporary information about the doings of that body, not to be found in its journals. Such information sometimes has the character of a record of the debates; more often it consists in less formal statements, addressed to the officials or political characters of the State represented by the writer, and recording the actions of Congress as seen from his personal point of view. When all brought together, in chronological order, this mass of correspondence should afford much fresh light on the course of Congressional transactions. Since the Continental Congress, which was much more than a merely legislative body, frequently

chose its executive instruments from among its own membership, it has been essential to draw a line between actions of Congress and actions of its administrative organs. Executive actions of Congress as a body are properly a portion of the work, but it will not include executive acts of committees or of individuals—*i. e.*, acts which individuals, whether members of Congress or others, performed in pursuance of general orders of Congress.

In the case of our projected edition of the Proceedings and Debates of Parliament respecting America it is in some particulars more difficult to fix the scope of the intended publication. It is plain that it should embrace the House of Lords and the Scottish and Irish parliaments, as well as the British House of Commons; that all printed and all discoverable manuscript sources should be drawn upon; that all matters which are located in North America by distinct geographical reference should be included. But since, on the one hand, the book will have in no particular a greater value than for the light it will cast on the commercial policy of Great Britain with respect to the colonies, and since that policy was a part of a general imperial policy in commercial matters, while, on the other hand, it is inexpedient to expand the book unduly by the inclusion of things only remotely American, many difficult questions arise, some of which are yet to be settled, as to the inclusion of parliamentary proceedings respecting such matters as British trade, duties, bounties, drawbacks, piracy, and Atlantic fisheries. The most competent advice has been sought, and all these points will soon be decided.

Miscellaneous Operations.—Another matter requiring expert advice, in a more organized form, is the preparation of a systematic plan for future historical publications on the part of the National Government. After the publication this autumn of a revised and enlarged edition of Van Tyne & Leland's "Guide to the archives of the Government of the United States in Washington"—*i. e.*, the preparation of an inventory—the next step, logically, in securing a proper historical use of the material in those archives would be that a competent committee, representing the most expert historical intelligence of the country, should frame a scientific plan, to be followed in the publication by the National Government of its volumes of documentary historical material. The Government now publishes many such volumes, but without concert between Departments and without general plan. Without the spending of more money than now, the effectiveness of what is done for historical progress would be manifold increased if a commission of scholars, having the confidence of the public and acting under the auspices of the Carnegie Institution of Washington, should, after due consideration of the gaps in our national historical record and the Government's materials for filling them, lay before Congress and the public a far-seeing general plan for national historical publications. Such a plan, framed by such a committee as I have had the honor to propose to the Trustees, would operate as a standard to be appealed to in the future, unofficial in origin, yet authoritative.

DEPARTMENT OF MARINE BIOLOGY,*

ALFRED G. MAYER, DIRECTOR.

The year 1906-07 has been the most successful in the history of the Tortugas Laboratory, and has been productive of more varied and important results in research than were either of the two previous years during which the Laboratory has been open to investigators.

The yacht *Physalia* was moored in the Miami River, Florida, when the center of the great hurricane of the autumn of 1906 passed over her, but, due to her strong hawsers and well-placed anchors, she was one of the few vessels in the Miami that survived the storm uninjured. A second menace to the prosperity of the Laboratory came through the fire on February 20, 1907, in the sail loft of the Miami boat-works, which destroyed the sails, running rigging, and much of the equipment of the *Physalia* and the *Sea Horse*. This loss was, however, covered by insurance and did not reduce the efficiency of these vessels in their work during the active season.

In order to render the *Sea Horse* more seaworthy and available for cruising in the Gulf Stream, she was extensively altered, the main object in these changes being to determine whether it will not be possible to carry out the scientific work of the Station with a smaller and less expensive vessel than the *Physalia*. Accordingly, the *Sea Horse* was provided with a self-bailing cockpit, a longer keel, and a mast; and thus equipped she proved so successful that it was found unnecessary to make use of the *Physalia* at Tortugas for any part of the scientific work of the Laboratory.

The *Physalia* was, however, placed in thorough repair and provided with a more efficient propeller and a canvas-covered deck for her trunk cabin; and thus equipped she made a cruise of more than 900 nautical miles through the Bahamas to Nassau and Cay Verde, leaving Miami on March 27 and returning on April 29.

The object of this cruise was to permit Mr. Frank M. Chapman, of the American Museum of Natural History, and Hon. George Shiras 3d to carry out studies upon the nesting habits of the frigate birds and gannets on Cay Verde, Bahamas. We also established a temporary laboratory at Nassau, leaving a launch, apparatus, and a sailor to serve Prof. Edwin G. Conklin, of the University of Pennsylvania, and Mr. Carl Kellner, assistant to Prof. William K. Brooks, of Johns Hopkins University. These gentlemen remained for a month in Nassau, carrying on studies in embryology upon certain of the pelagic animals living in the deep water of the Tongue of the Ocean, beyond the mouth of Nassau Harbor.

In the meantime the yacht proceeded to Cay Verde, making frequent pelagic hauls en route.

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* Situated at Tortugas, Florida. Grant No. 398. $15,000 for investigations and maintenance. (For previous reports see Year Book No. 3, pp. 50–54; Year Book No. 4, pp. 108–124; and Year Book No. 5, pp. 106–118.)

On behalf of the Department of Marine Biology, it is a pleasure to express our gratitude for and appreciation of the courteous kindness of His Excellency Sir William Grey-Wilson, who, as governor-in-council, permitted the expedition to carry out scientific dredgings among the Bahama Islands and to collect specimens of the frigate birds on Cay Verde.

Our voyage among the Bahamas proved to be the most adventurous the yacht has yet encountered. On April 1, 1907, a strong southerly gale forced us into a harbor of refuge under the lee of Elbers Cay, about 50 miles southeast of Nassau. The sun was about to set when, on the northern horizon, vast masses of black clouds suddenly arose, driving before them the heavy breakers of the oncoming storm, and in an instant the wind reversed and we found ourselves dragging anchors toward the rocks of a coral reef. With all haste we got the yacht under way. It proved impossible to steam up into the gathering storm, and we had no choice but to scud before it; "jumping" a bar with less depth than our draft, and sailing out between the jagged masses of rock, we reached the open water, where we met the roughest sea the *Physalia* had encountered since she was launched. At midnight the naphtha-tank burst, through the excessive rolling of the vessel, and, with all lights out and only an electric "candle" held close to the binnacle, we went on through the night under storm sails, and when the morning broke we were more than 100 miles away from our former anchorage. A large bark foundered near us in this storm, and a yacht larger than the *Physalia,* which left Miami with us, was never again heard from. However, the *Physalia* returned to Miami in excellent condition, her seaworthy qualities having been thoroughly tested.

Messrs. Chapman and Shiras remained on Cay Verde from April 8 to 12, inclusive, and obtained a complete series of specimens of the young seabirds and a large number of photographs illustrating their nesting habits. The results of these studies will be published by Mr. Chapman and are briefly referred to in his preliminary report presented herewith. A practical result of the expedition will be the construction of a "group" in the American Museum illustrating the nesting habits of the frigate birds and gannets of the Bahamas.

An actuating motive which prompted the setting out of the expedition was that for the past three years the pelagic tours at Tortugas, Florida, have been very poor in comparison with those of 1897-99. Accordingly, between March 15 and July 31, 1907, the laboratory vessels cruised over 2,000 miles, making frequent surface and intermediate hauls, but everywhere we met with uniformly poor success. As these tours covered the wide region beyond the Columbus Bank to the Tongue of the Ocean, and on both sides of the Gulf Stream, and along the Barrier Reef of Florida to Tortugas, it is evident that the poverty of pelagic forms is not local and peculiar to the Tortugas, but is widespread and cyclical. It appears that the whole pelagic fauna

of a wide region may be depleted in certain years, very much as upon land there may be "insect years" and years of general scarcity.

The result of the voyage was to confirm my impression that the Tortugas affords the best possible situation from which to study the marine life of the tropical Gulf Stream. This view is confirmed by that of Dr. Robert Hartmeyer, of the Berlin Zoological Museum, a most successful collector and able student of marine life, who has made extensive collections in Jamaica, St. Thomas, Barbados, Trindad, Cuba, and other parts of the West Indies. Dr. Hartmeyer's opinion of the Tortugas is expressed in detail in his preliminary report presented herewith.

The following investigators studied under the auspices of the Department of Marine Zoology during the past season:

Mr. Frank M. Chapman, American Museum of Natural History, March 27 to April 29.
Prof. Edwin G. Conklin, University of Pennsylvania, March 28 to April 23.
Dr. Robert Hartmeyer, Berlin Zoological Museum, May 24 to July 9.
Prof. H. E. Jordan, University of Virginia, May 17 to June 12.
Prof. Edwin Linton, Washington and Jefferson College, June 27 to July 18.
Prof. Jacob Reighard, Michigan University, July 8 to August 9.
Dr. Charles R. Stockard, Cornell Medical College, June 5 to July 23.
Dr. Frank A. Stromsten, Iowa University, June 5 to July 23.
Prof. John B. Watson, Chicago University, May 2 to July 18.

In addition to the above, Messrs. Carl Kellner, of Johns Hopkins University, and Davenport Hooker, of Yale University, acted as artist and collector respectively.

Effective precautions are taken to prevent the breeding of mosquitoes upon the Loggerhead Key, and the utmost cleanliness is maintained about the premises. The rations consist of the best procurable canned provisions, supplemented by fruit, fish, and turtle-meat, but no fresh vegetables or unpeeled fruit is brought to the island from Key West, owing to the possibility of the introduction of various tropical diseases. The almost constant sea-breeze and the excellent ventilation of the laboratory buildings maintain a degree of coolness which is exceptional in tropical latitudes. The highest temperature ever observed in the laboratory was 97° F., but this was at least 10° above the usual degree of heat in the warm season.

All of the investigators returned in excellent health, the majority being evidently benefited by their life in the open air, such as the laboratory affords.

REPORTS OF RESEARCHES.

Mr. Frank M. Chapman presents the following report upon his observations of the frigate birds and gannets nesting upon Cay Verde, one of the most isolated and inaccessible of the Bahama Islands. This island is a mass of jagged and eroded rock, and, with dangerous coral reefs on one side and the deep ocean on the other, it affords no harbor. Mr. Chapman's studies were therefore carried out at much personal hardship and considerable risk,

for the yacht would have been unable to remain near the island in the event of any sudden storm, and even moderately rough weather prevented one's landing upon or leaving the rocky shores. Despite these circumstances Mr. Chapman achieved that success which has distinguished his studies of the birds of many other isolated and storm-beaten islands.

Preliminary Report on the Results of a Trip to Cay Verde, Bahamas, to Secure Material for "Habitat Groups" of Man-o'-war Birds (Fregata aquila) and Boobies (Sula fiber), by Frank M. Chapman, American Museum of Natural History.

The American Museum of Natural History has in process of formation a series of groups of North American birds, designed to show the nesting habits of certain species, as well as to illustrate the country which they inhabit. These groups contain the birds, often shown in various stages of development, the nest and its contents, while the immediate surroundings are reproduced in detail. In addition to this representation in facsimile of a portion of the country, a background painted from nature is so joined to the actual group that the whole appears to be continuous. An adequate conception is thus conveyed of the breeding habits as well as habitat of the species treated.

More or less difficulty has been experienced in securing material and making the field studies for some of these "habitat groups," as they have been termed, in localities remote from regular lines of transportation. When, therefore, it was decided to send the writer to Cay Verde, Bahamas, to secure material for groups of man-o'-war birds and boobies, the Museum gladly availed itself of the cooperation of Dr. Alfred G. Mayer, Director of the Marine Biological Laboratory of the Carnegie Institution, who not only consented to place the *Physalia* at the service of the Museum for the trip from Nassau to Cay Verde, but further increased the Museum's indebtedness by taking command of the boat.

Cay Verde is situated at the eastern extreme of the Columbus Bank, some 250 miles southeast of Nassau. After securing permission of the Bahama government to collect specimens of the birds required, we sailed from Nassau on the morning of March 31, adverse weather conditions delaying our arrival at Cay Verde until the afternoon of April 8.

In the absence of definite information, more or less doubt existed as to the proper season at which to visit this cay in order to secure eggs and the young of the species desired, but we arrived at a time wholly favorable for our purpose. It was estimated that about 3,000 boobies (*Sula fiber*) were nesting on the cay. Most of the nests contained a single half-grown bird, but in a number of instances freshly laid eggs were found, while a few birds of the year were already on the wing. Between these extremes every intermediate stage existed. Similar conditions prevailed among the man-o'-war birds (*Fregata aquila*), which, however, were less numerous than the boobies, it being estimated that not more than 600 were nesting on the cay.

Mr. George Shiras 3d and the writer were encamped on the Cay Verde from April 8 until the evening of April 11, while the *Physalia* was anchored first on one side of the cay, then on the other, as the wind required. During this period all the needed collections of birds, from those newly hatched to fully adult specimens, nests, eggs, vegetation, and other accessories were

made. A large series of photographs illustrative of the character of the island and its bird-life were secured, together with statistical material and notes on the habits of the birds and sketches in color of fresh specimens and of the island itself.

Prof. Edwin G. Conklin continued his studies upon the protoplasmic differentiation of the eggs of the scyphomedusa *Linerges,* which was at times abundant during March and April in Nassau Harbor. He is, however, unable to discover any definite "organ-forming substances" in this egg, such as he so clearly demonstrated the existence of in the eggs of tunicates. Professor Conklin's researches, however, enabled him to discover a new and remarkable fish, a new polychæte norm, and to make a study of the normal development of *Linerges* itself.

Dr. Robert Hartmeyer, of the Berlin Zoological Museum, studied for two months in the Tortugas Laboratory, and during his visit he made an extensive general collection of the animals of the reefs and channels, devoting special attention to the ascidians, in which group his collection is far superior to any previously made in the Tortugas region.

Preliminary Report on the Ascidians of the Tortugas, by Dr. R. Hartmeyer, Assistant at the Berlin Zoological Museum.

I spent nearly two months on the Tortugas, from the middle of May until the middle of July, in order to make general collections of marine animals for the Berlin Zoological Museum and to study particularly the ascidians of these islands. On different scientific trips I have visited several parts of the tropic seas, but have found no place for collecting and studying the marine fauna in so satisfactory a manner as at the Marine Laboratory of the Carnegie Institution of Washington. Some groups of marine animals, for example the gorgonians and the milleporids, may be studied here alive, and experiments upon them may be better made here, perhaps, than anywhere else in the world. These animals grow in a large number of species and individuals just in front of the laboratory in very shallow water, and can be obtained at low tide without difficulty and brought quite fresh into the laboratory for further study. There are found here a very rich pelagic fauna and an abundant reef fauna, and also a very interesting and yet little-known fauna of the deeper channels between the flats—quite different from that of the coral reefs.

The ascidians, which I particularly studied, are one of the most abundant groups of marine animals at the Tortugas, especially in the deeper water of the southwest channel and under the large stones along the shore of Loggerhead Key. On the dead part of the coral reef there are only a few forms, but on some parts of the living reef one will find many different species incrusting the big clusters of *Torites clavaria.* I collected at least 40 or 50 different species, most of them compound ascidians. But many more forms will surely be found, especially in the deeper water, than I could collect during my comparatively short residence at the laboratory. If we consider that only four species of compound ascidians have been described from the

whole West Indies, we may expect that many of the forms collected at the Tortugas are new to science. Very abundant is the genus *Leptoclinum.* Next to it the Botryllidæ are represented by a large number of prettily colored forms; most of them are probably only varieties of one and the same species. Of other genera, hitherto not yet known from the West Indies, I may mention *Styela, Perophora, Stereoclavella, Polyclinum, Tolycitor,* and *Diplasoma,* which are represented in my collections by one or several species. Among the Styelidæ there are some very interesting forms belonging to the subfamily of the Polyzainæ. Besides these forms, most of the common and well-known West Indies ascidians are also represented at the Tortugas; for example, *Thallusia nigra* (synonymous to *Ascidia atrales*), *Ascidia hygomiana, Ascidia curvata, Halocynthia riiseana, Polycarpa obtecta,* and so on. I was somewhat surprised not to find here the interesting tropical genus *Rhodosoma,* which has been collected at different localities of the West Indies.

It was of especial interest to compare the marine fauna of the Tortugas with that of St. Thomas, Barbados, and Jamaica, where I collected with Professor Kirkenthal for about four months before I came to the Tortugas. Generally speaking, the littoral fauna of the whole West Indies seems to be very uniform. There are many characteristic and typical forms widely distributed all over the West Indies, but at some places less abundant than at others. Nevertheless, I noticed some remarkable differences between the Tortugas and the other islands I visited. On the Tortugas reefs I found in great abundance some species of ophiurans, which I did not collect at any other place. On the other hand, the extremely common West Indian starfish *Tentaceras reticulatus* is very rare at the Tortugas, while other species, for example *Madrepora palmata* and the yellow-colored form of *Rhipidogorgia flabellum,* are entirely wanting. These are only a few examples, but I hope to find an occasion, later on, to publish some more detailed facts, based on the study of my collections.

Mr. Davenport Hooker made some interesting observations upon the reactions of the newly hatched loggerhead turtle, and presents the following preliminary report:

Preliminary Observations on the Behavior of Some Newly Hatched Loggerhead Turtles (Thalassochelys caretta), by Davenport Hooker, Yale University.

Inasmuch as there are prevalent various ideas concerning the action of young sea-turtles in reaching the ocean after they are hatched, a series of experiments was performed this past summer (1907) at the Marine Biological Station of the Carnegie Institution of Washington at Tortugas, Florida, to discover, if possible, just what factor or factors determine the behavior of the loggerhead turtle in this respect, and to find out something about the early habits of this species. By eliminating certain features, such as light, sight of the ocean, etc., the following very definite results were obtained:

(1) Newly hatched loggerhead turtles have two inherent tendencies: first, to enter hollows, and, second, to go toward the point of greatest illumination. Both of these tendencies may act together to the slight detriment of the second, but either one would eventually lead the animal to the sea, as the shores always slope down to the water and the reflected light from the water

is stronger than from any other natural source. When attempts are made to hinder the course of the animal to the ocean, it immediately falls back on these two tendencies to guide it till the ocean is again in sight.

(2) Hearing the surf or smelling the water certainly do not enter into consideration. This is borne out by the fact that where direct rays of the sun were eliminated the turtles moved in all directions with equal readiness, though they were but 20 feet from the water, at which distance both the sound and the smell of the water must have been evident.

(3) Their tendency to move in the direction of the greatest illumination disappears in less than 12 hours after hatching.

(4) After entering the water these turtles have a definite period of "getting out to sea," followed by a definite period of rest, the process of getting out to sea being governed, as far as direction is concerned, by the source of the strongest illumination.

(5) The edibility or non-edibility of a substance must be determined for every new object encountered.

Prof. H. E. Jordan, of the University of Virginia, carried out cytological studies upon echinoderm eggs, these being a continuation of his previous work at Woods Hole upon the eggs of the common starfish. While at Tortugas he devoted special attention to a study of the eggs of the large sea-urchin *Hipponoë esculenta.* His preliminary report is as follows:

Preliminary Report on a Comparative Cytological Study of Echinoderm Eggs, by H. E. Jordan, University of Virginia.

My chief object in spending a month at the laboratory at Dry Tortugas was to collect material for a comparative cytological study of the maturation phenomena in various echinoderm eggs. Primarily I desired to determine the relation between chromosomes and nucleolus in the maturing oöcyte. It has been claimed for several echinoderm forms that the chromosomes at maturation arise from the nucleolus. I have shown that in *Asterias forbesii* the chromosomes originate from the nuclear reticulum at the beginning of the growth period of the primary oöcyte, persist as a mass of minute bilobed bodies, sometimes in close proximity or even superficially attached to the nucleolus, and at maturation are drawn into the first polar spindle, while the nucleolus fragments and contributes chromatin to the chromosomes, by virtue of which they grow slightly in size. The residue of the nucleolar fragments are resorbed by the cytoplasm. The main problem of this investigation is to discover the source and manner of origin of the chromosomes in the oöcytes of available echinoderms, and to see whether the normal method actually differs in essentials among different forms or only in minor details. I have thus far been able to extend my research only to include *Hipponoë esculenta,* a large, white-spined sea-urchin, very abundant in the shallow waters of the reefs in the vicinity of Dry Tortugas. I have on hand material also of two ophiurans, *Ophiocoma riisei* and *O. pumila,* which began to ripen just as I was leaving the Keys, the middle of June, and to which study will shortly be devoted.

Besides the forms already mentioned, I collected ovarian material also from *Diadema setosum, Linchia guildingii, Clypeaster subdepressus, Cidaris*

sp., *Stichopus mœbii, Echinaster crassispina,* and *Holothuria mexicana.* In all of these forms the gonads appeared in very immature state, with the exception of *Holothuria mexicana.* Dr. Mayer kindly offered to preserve eggs of the latter in maturation phases, but reports that when he left the Keys, in the latter part of July, the eggs were still unripe. Only a single specimen of *Echinaster* was found at Tortugas, but sections of the ovary show that this is a highly promising form for future study. I have since learned that this echinoderm is very abundant at the Marquesas Keys, and I hope to be able to procure material during another summer.

The eggs of *Holothuria mexicana* appear very peculiarly favorable for purposes of the present investigation, and it is a source of deep regret to me that I could not procure ripe material before the laboratory closed for the season. Attempts were made to force the eggs to mature by artificial means, such as warming the water, agitation, acid solutions, and the addition to the sea-water of the active spermatozoa of *Hipponoë,* but to no avail. The egg of *Holothuria mexicana* has a large micropyle; the spermatozoa of *Hipponoë esculenta* are small and very active; theoretically it should be possible to make a very pretty and highly interesting cross between the two. Various ophiurans to all appearances offer equally favorable spermatozoa for such a cross. The great abundance of echinoderms furnishes material for the solution of many problems to one fortunate enough to be in the waters of Tortugas during the proper seasons. One is strongly impressed with the fact that in the tropics the breeding seasons of the animals are just as definite and as sharply limited in time as in the temperate zones.

The egg of *Hipponoë esculenta* has two or more nucleoli, thus contrasting sharply with *Asterias forbesii,* which has constantly only one. Furthermore, the egg matures in the ovary, and this fact renders it less favorable for a study of maturation phenomena than the egg of *Asterias,* which matures after being shed into sea-water. However, sections of ovarian material gave sufficient of the maturation phases for the study contemplated. Attempts were made to cause immature eggs to mature in sea-water under stimulus of agitation, acids, etc., but without success. But unfertilized mature eggs could be induced to undergo the first two segmentation divisions under the stimulus of a drop of HCl added to the sea-water. Controls showed the complete absence of spermatozoa from the water.

In *Hipponoë* two polar bodies are formed, the first never being seen to divide. The reduced number of chromosomes is approximately 18 and maturation appears to take place by a double longitudinal division. Concerning the earlier stages of the maturation process, more definite statements can be made. The chromosomes arise from the nuclear reticulum, which assumes the form of a loose spireme and increases in chromatic content probably at the expense of the vanishing nucleoli. The stout spireme contracts into a closely tangled knot and then segments into the reduced number of chromosomes, which are presently drawn into the first polar spindle. Thus the chromosomes, in contrast to what occurs in *Asterias,* where they are formed at the beginning of the growth period and persist with identity unimpaired, are merged with the nuclear reticulum and only arise as recognizable chromosomes at the very close of the growth period. Similarly, then, as in *Asterias,* the chromosomes originate from the nuclear reticulum and receive chromatic material, probably a nutritive substance, from the disappearing nucleoli just prior to their entrance into the first polar spindle.

Prof. Edwin Linton continued his studies of the parasites of fishes and other animals at Tortugas with admirable success. His results are important from an economic as well as from a purely scientific standpoint. Professor Linton's skill as an observer is unexcelled in this field among American zoologists. His preliminary report of this summer's work is as follows:

Preliminary Report on Animal Parasites, by Edwin Linton, Washington and Jefferson College.

During my stay at the laboratory, June 27 to July 19, I continued work on the helminth fauna of the Tortugas, with especial reference to the entozoa of the reef fishes. As in 1906, so this year, I found very few acanthocephala and nematoda. Encysted cestodes were also found to be of less frequent occurrence than they are at Beaufort or on the New England coast. Trematodes were more abundant than the other orders, and there is reason to think that they are more prolific in species than they are in northern waters.

One form of distome, found rather frequently in the grunts and sparingly in a few other fish, is peculiar in that its ova are provided with a long filament. The species has not yet been determined. It does not agree with any of the genera in Pratt's Synopsis.

Many species of distomes were added to last year's list. Thus the 3 specimens of spotted moray (*Lycodontis moringa*) yielded 5 species of distomes not found in this host last year; and 3 black angel-fish (*Pomacanthus arcuatus*) yielded 3 species which were not found in the specimen examined last year, wrongly recorded under the name *Chætodipterus faber.*

No selachians were taken while I was at the laboratory this year. One small nurse-shark (*Ginglymostomum cirratum*) had been taken before my arrival, from which were obtained a few specimens of a species of *Ascaris,* not found last year, and 2 species of cestodes similar to forms collected from this host last year. After I left the laboratory, Mr. Davenport Hooker collected from a cub-shark (*Carcharhinus lamia*) some cestodes, which I have since examined. As I have already made a report on the cestodes collected in 1906, I take this opportunity of recording the cestodes from this species of shark, which is not included in last year's list:

Crossobothrium angustum, or near it; 3 scoleces and a few fragments, from the spiral valve.

Phoriobothrium lasium, 15, from the spiral valve.

Otobothrium penetrans, 1 adult from stomach. This name was given to an immature form found in the flesh of the gar (*Tylosurus acus*) in Bermuda. This is therefore the first record of the adult of this species.

In the Year Book of the Carnegie Institution for 1906, page 116, I stated that the spiral valve of a shark which had been kept in formalin until my arrival at the laboratory belonged to a tiger-shark (*Galeocerdo tigrinus*). As the identification was a somewhat unusual one, being based in large part on the character of the stomach contents and the entozoa, I embrace this opportunity of confirming the identification. Having learned from Dr. Mayer that the jaws of the shark in question had been sent to the museum of Harvard University, I wrote to Prof. Samuel Garman, who replies that the jaws are the jaws of *Galeocerdo tigrinus.*

List of Hosts Examined in 1907 and Summary of Results.

Host.	No. of hosts examined.	Acanthocephala.	Nematoda.	Cestoda.	Trematoda.	Ectozoa, etc.
Ginglymostomum cirratum (nurse-shark).	1		1 species, few	3 species, few		
Carcharhinus lamia (cub-shark)	1			3 species, few		2 leeches.
Lycodontis moringa (spotted moray).	3				5 species, few	
Lycodontis funebris (green moray).	1			1 cyst	3 species, one numerous.	
Sphyræna barracuda (great barracuda).	1				1 species, few	
Epinephelus striatus (Nassau grouper).	3		1 species, immature	1 cyst	2 species, few	
Epinephelus morio (red grouper)	2			Dark-brown nodular cysts on viscera and in stomach wall.	1 species, few	
Mycteroperca venenosa (yellow-finned grouper).	2		Few, encapsuled on viscera.	2 species, encapsuled and degenerate cysts.	2 species, few	Isopod in nostril.
Mycteroperca microlepis (gag)	1		1	1 species, cysts on viscera.		
Neomænis griseus (gray snapper)	10		3 species, few	1 species, encysted	1 species, numerous	
Neomænis apodus (school-master)	8		1 species, immature	3 cysts on viscera	2 species	
Ocyurus chrysurus (yellow-tail)	9		1 species, immature	1 species, few	5 species, few	Copepod from gills.
Hæmulon macrostomum (striped grunt).	3				4 species, few	
Hæmulon sciurus (yellow grunt)	21	1 specimen and fragment.	1 species, few, immature.		6 species, few	Isopod from gills.
Hæmulon plumieri (white grunt)	107	1 specimen	2 species, one immature.	1 cyst	12 species, few	
Anisotremus virginicus (porkfish).	1				3 species, few	
Calamus calamus (porgy)	3		1, immature		6 species, few	
Kyphosus sectatrix (chub)	5		1, immature	2 cysts	3 species, few	Copepod from gills; cysts of Myxobolus species, cysts on intestine.
Pomacentrus planifrons (black pilot).	6		1, immature	1 cyst		Copepod from gills.
Abudefduf saxatilis (cow-pilot)	1			1 cyst	1	Sporozoa in small cysts in mucous membrane of intestine.
Iridio bivittatus (slippery Dick)	6			Few small larvæ	1 species, few	
Chlorichthys bifasciatus	2		1, immature	Few small larvæ	2 species, few	
Scarus cæruleus (parrot-fish)	1					
Pomacanthus arcuatus (black angel-fish).	3				5 species, one of them numerous.	1 copepod from gills.
Teuthis hepatus (surgeon-fish)	1				4 species, few	
Lactophrys triqueter (cow-fish)	1					
Thalassochelys caretta (loggerhead turtle).	2		3 species		5 species, two of them numerous.	Leeches and barnacles in mouth.
Fregata aquila (man-o'-war bird)	1		1 species, few	1 species, many		

Comparative Results of the Examination of Individuals of the Same Species for Distomes in 1906 and 1907.

Name of host.	1906.		1907.	
	No. of hosts examined.	No. of distomes found.	No. of hosts examined.	No. of distomes found.
Lycodontis moringa	1	1 species, few	3	3 species, few.
Lycodontis funebris	1	3 species, one of them numerous.	2	3 species, one of them numerous.
Sphyræna barracuda	7	1 species, few	1	1 species few.
Epinephelus striatus	9	2 species, few	3	2 species, few.
Mycteroperca venenosa	1		2	2 species, few.
Neomænis griseus	41	4 species, many	10	3 species, many.
Ocyurus chrysurus	3	1	9	5 species, few.
Hæmulon macrostomum	2	2 species, few	3	4 species, few.
Hæmulon sciurus[1]	1		21	6 species, few.
Hæmulon plumieri[2]	35	8 species, mostly represented by few examples.	107	12 species, mostly represented by few examples.
Abudefduf saxatilis	1	1	1	1
Chlorichthys bifasciatus[3]	1	4 species	2	2 species, few.
Pomacanthus arcuatus[4]	1	4 species, one of them very numerous.	3	5 species, one of them very numerous.
Thalassochelys caretta	1	2 species, one of them very numerous.	2	5 species, one of them very numerous.

[1] Hæmulon flavolineatum in 1906 report.
[2] Hæmulon sciurus in 1906 report.
[3] Iridio kirschii in 1906 report.
[4] Chætodipterus faber in 1906 report.

Two specimens of the loggerhead turtle (*Thalassochelys caretta*) were examined. From them 3 species of nematodes and 3 species of trematodes were secured, which were not seen in this host last year. In the mouth of one of these turtles numerous specimens of a species of *Branchiobdella* were found, and in the mouth of the other many barnacles. They were firmly attached to the floor and roof of the mouth and at the beginning of the gullet.

The alimentary canal of a man-o'-war bird (*Fregata aquila*) was brought to the laboratory by Prof. J. B. Watson. Three specimens of an ascarid were found in the stomach and many specimens of a cestode were found in the intestine.

Prof. Jacob Reighard continued his studies of 1905 upon the subject of warning coloration in reef fishes. Naturalists have commonly assumed that the small, brilliantly colored fishes that haunt the crevices of the coral reefs are probably warning-colored, and are distasteful to the predatory fishes of the reefs. Professor Reighard has clearly demonstrated that such is not the case, for these conspicuously and beautifully colored fishes are readily devoured by the commonest predatory fish of the reef, the gray snapper, whenever they are removed from the protection of the coral-heads. Professor Reighard proved, nevertheless, that the gray snapper could be taught to associate an evil taste with conspicuous color in artificially dyed and poisoned fishes, and that they would "remember" to avoid such fishes even 20 days after their evil experience. It is thus evident that while "warning coloration" is a possibility, none of the brilliantly colored reef fishes which Dr. Reighard experimented with are warningly colored.

I consider his experiments to be the most conclusive and his results the most uniform and the clearest yet attained by any naturalist in experiments upon the subject of warning coloration. No account of his experiments can give an adequate idea of the dramatic definiteness of his results. As the theory of "warning coloration" has been one of the cornerstones of the theory of natural selection, it is unnecessary to call further attention to the importance of Professor Reighard's results. His preliminary report is as follows:

An experimental Study of Color Discrimination, Association, and Memory in the Gray Snapper, Lutianus griseus (Linnæus), and of Warning Coloration in Coral-reef Fishes, by Jacob Reighard, University of Michigan.

The gray snapper, the commonest predaceous fish of the coral reefs at Tortugas, Florida, was made the subject of experiments intended to test the following underlying assumptions of the theory of warning color as applied to coral-reef fishes: (1) That there is "a general association of bright colors with poisonous or dangerous qualities" (Beddard), so that certain colors in themselves warn the predaceous reef fish and are avoided by them; (2) that the predaceous species discriminate colors; (3) that they are able to form associations between certain colors and disagreeable qualities; (4) to retain these associations (memory).

The commonest food of the gray snapper, in May or June, is a small silvery fish, *Atherina laticeps* Poey. The experiments consisted in feeding to the gray snappers dead Atherinas, to which different colors had been given by the use of dyes. The tests were made upon a colony of 150 snappers, entirely at liberty in their natural environment under wholly normal conditions.

(1) The snappers took without hesitation Atherinas when colored red, yellow, green, blue, or violet.

(2) By feeding the snappers on Atherinas of one color until they were familiar with it, and then allowing them a choice between that color and another and unfamiliar color, they were found to discriminate white from blue, blue from red, and blue from yellow. Care was taken to eliminate errors due to differences in brightness-values, size, position, and chemical qualities (odors or taste). The colors were impure.

(3) Red Atherinas were rendered unpalatable by attaching to each a small portion of a nettle-cell bearing tentacle of the medusa *Cassiopea;* 238 tentacled Atherinas were fed to about 150 snappers in 1 hour and 35 minutes, divided into two nearly equal periods, separated by an interval of 3 days; 60 of the tentacled Atherinas (including the last 16) were refused. That the association thus formed was between disagreeable qualities and the color red, and not between disagreeable qualities and the changed form of the red Atherinas due to the attached tentacles, was shown by the following: (*a*) That red Atherinas without tentacles were subsequently refused, while (*b*) white Atherinas with tentacles were readily taken. Twenty days after the red association had been formed, red Atherinas without tentacles were still absolutely refused by all the snappers in the colony, although white and blue were readily taken (retention of a warning association artificially established).

Individuals of 20 species of coral-reef fishes were fed, living, to the same colony of snappers. They were conspicuous in color and pattern, many of them typically "warningly" colored. All were readily taken.

While the gray snapper is thus shown to possess the qualities necessary to the establishment of a warning reaction (assumptions 2, 3, and 4), and while such a reaction may be artificially established (assumption 3) and is long retained (assumption 4), yet feeding experiments furnish no evidence of the avoidance of any color in itself (assumption 1) or of the existence in coral-reef fishes of that combination of conspicuous coloration and disagreeable qualities necessary to the theory of warning color.

Dr. Charles R. Stockard carried out an interesting series of studies of the habits of a walking-stick insect, which is common upon the bay cedars of the Tortugas, and he also conducted elaborate observation of certain phenomena of regeneration in *Cassiopea.* Detailed studies of the normal relations of supposedly "protectively colored" insects have not hitherto been made. The habits of the insect studied by Dr. Stockard are such as would reinforce the efficiency of its remarkably "protective" coloration. Dr. Stockard's preliminary report of his studies is as follows:

Summary of Investigations Conducted at the Carnegie Laboratory for Marine Biology, Tortugas, Florida, Season of 1907, *by Charles R. Stockard, Cornell University Medical College, New York City.*

(1) A study was made of the behavior of *Aplopus mayeri,* a "walking-stick" found to be rather common on the island. Its wild habits, such as movements, feeding, mating, etc., were observed, and the insects were seen to be nocturnal, becoming active and moving about on the food-plant shortly before sunset. This activity was kept up until the faint daylight of morning, when they came to rest on any part of the limb that they happened to be at this time. They assume a protective attitude during the day and are extremely difficult to locate. The females vary considerably in color, as do the stems of the food-plant, *Suriana maritima,* though they seem to fail completely to take advantage of this variation, the light-gray type of female often resting on the darker branches, and *vice versa.* When disturbed, they usually drop bodily from their position and catch on a branch below, or, at times, fall entirely to the ground, where they may feign death and sometimes lie motionless on their backs for several minutes. Most of the habits of this protectively constructed animal are much the same as one would imagine to be most advantageous to their possessor under the given conditions.

The mating habits were closely studied. They were found to pair most frequently at night, though several pairs were observed *in copulo* during the mid-day.

A number of experiments were conducted to test the modification of their behavior. The eyes were blackened; antennæ removed; they were subjected to various noises and colored lights, and studied in the dark-room during the day. The details of these experiments will be published in the contributions from the Laboratory.

Experiments were also conducted to test the mating instincts of *Aplopus.* I finally succeeded in inducing two males, at different times, to copulate

perfectly with a portion of the abdomen, which had been cut from a mature female and then fixed to a stick supported by wire "legs." This, I believe, is the first successful experiment to cause a male insect to pair with a portion of a female or even with one fatally disabled.

(2) A small minnow, *Atherina laticeps,* was used to test the influence of the osmotic pressures produced by solutions of glucose and cane-sugar, as well as to ascertain the resistance of this fish to dilute and concentrated sea-water solutions. Hypertonic solutions were found to be decidedly more injurious than hypotonic, the fish often living longer in the latter than in normal sea-water. No difference could be observed between the effects produced by the two kinds of sugars. This fish is rather delicate and not a favorable subject for such studies.

(3) A series of experiments were conducted to find, if possible, some relation between the extent of injury and the rate of regeneration, also to test the influence of movement or activity on the regeneration rate, as well as the influence of the nervous tissues. Finally, the effects of the metallic ions Ca, K, Na, and Mg on regeneration were studied for comparison with the influences that these elements are known to produce on contractile tissues. The animal used in these experiments was the very hardy jelly-fish *Cassiopea xamachana,* so abundant in this region. I found *Cassiopea* favorable material for such studies, since its circular shape and radial structure enables the observer to perform several experiments on one and the same individual, thus facilitating comparisons; for example, a ring of tissue cut from the periphery of this jelly-fish will readily begin to regenerate. Now, with such a preparation one may remove the sense-organs from half the ring, then insulate the two halves, causing one to cease pulsating while the other maintains its normal pulsations. Thus the influence of rest and activity may be observed on the regenerating surface. Many such experiments are made possible with this animal.

Individuals having a number of mouth-arms removed regenerate these arms at rates which vary as much as does the rate of regeneration between the individual with one or a few removed arms and others with many arms removed. In other words, I do not find it to be always the case that the individual having the larger number of removed appendages regenerates each of these arms more rapidly than will an individual with fewer removed arms. I have not, however, up to this time, had an opportunity to make a careful study of the measurements contained in my notes, and it may possibly be that on calculating averages the results may accord more closely with those of Zeleny.

Tissues removed from various parts of the disk regenerate more rapidly the nearer they are to the disk center and less rapidly as the periphery is approached. Cuts of different shapes were made in the disk, and in all of these experiments the manner of regeneration from the different parts of the cuts was identical with that which Morgan has found for the regenerating fish's fin. The detailed results of this investigation will be published by the Carnegie Institution.

Dr. F. A. Stromsten preserved about 450 embryos of the loggerhead turtle in various stages of development, with a view to a determination of the development of the venous system. He will be unable to report upon this research until he has completed the study of extensive series of sections.

Prof. John B. Watson carried out what I believe to be the first continuous series of observations of the reactions and instincts of sea-gulls during their nesting period. His preliminary report gives an inadequate idea of the remarkable extent of his experiments or of the clearness of his results. Among other things, he demonstrated that if the sooty terns and noddies were taken to Cape Hatteras and then liberated they would return to their nests on Bird Key Tortugas, a distance of 850 statute miles from their place of liberation.

As Professor Watson states in his preliminary report, one season's work is not sufficient in which to complete the study of so complex a series of instinctive reactions as those of nesting gulls, and it is to be hoped that he may continue his observations.

His studies were carried out under circumstances so trying that but few men of science would have had the resolution or have maintained the interest necessary to conduct the experiments. He lived continuously upon Bird Key for 2 months, through the hottest season, when the temperature of the sand upon which the birds lay their eggs rose to 120° F. He lived in the old deserted yellow-fever hospital which was used when the island was a quarantine station, yet he pursued his observations with an energy and devotion rarely surpassed.

Professor Watson's preliminary report is as follows:

A Résumé of a Study upon the Behavior of Noddy and Sooty Terns Carried on at Bird Key during the Spring of 1907, by John B. Watson, University of Chicago.

From May 2 to July 18, accurate field observations were made upon the instinctive life of noddy and sooty terns. The complete report of this work will include the behavior of the birds during the laying, brooding, and rearing periods. These birds have a large series of instinctive activities, which are displayed in rhythmical order, depending upon the state of advancement of the nesting period. The attempt was made accurately to determine:

(1) The natural stimuli calling forth the instinctive responses.

(2) The extent to which these responses are variable.

The work here, as elsewhere, is preliminary. The life of the birds is so complex, and its study so beset with difficulties, that one season of observation can nowhere give final results. It is worthy of note here, that an accurate study of the instinctive life of the birds must be at hand before controlled experimentation can be undertaken. The study of the psychology of any particular species of animal becomes possible and practicable only after its hereditary coordinations have been carefully noted.

Controlled experimentation as contrasted with field observation was undertaken in two ways: (1) By using the "nest environment" (possible only after the egg has been laid) as a stimulus; (2) by using hunger as a stimulus with young birds reared by hand.

(1) The writer found that the "nest environment" was a stimulus sufficiently strong to force the birds to overcome difficulties in getting to the nest; consequently we have here a method for controlling the reactions of the birds

under natural conditions, similar to the one now used in laboratory experimentation upon animals, namely, that of using food as a stimulus. With the "nest environment" as a stimulus, a variety of "problem boxes" was presented to the adult terns, and the behavior of the birds noted as they, at successive trials, gradually succeeded in overcoming the difficulties in the way of reaching the nest. In this way the range of associations, the time of formation of associations, the permanency of associations, etc., may be determined. On account of the limited time, this work was carried only far enough to demonstrate the feasibility of the method.

(2) The young of both species were successfully reared by hand. Their development was normal. Young so reared showed few signs of fear when being experimented upon. Some of the work of Lloyd Morgan, Spaulding, and others was verified. The most important observations in this connection were made upon the "perfection of instincts by habit"—many coordinations were found to be imperfect at birth, but were rapidly perfected through "trial and error." By keeping daily notes upon the development of the young birds, a genetic statement of the rise and development of their instincts was made possible. When the birds became sufficiently developed to withstand a moderate degree of hunger, efforts were made to study their method of forming associations. The simple maze of Porter (Amer. Jour. Psy., vol. XVII, pp. 248–271) was presented to both the noddies and the sooties. It was learned by them in a time comparable to that of the pigeon in forming the same association. Again, owing to the limitations of time, no wide range of problems could be presented to the young birds.

An effort was made to determine the distance to which the birds go in obtaining their food. For the present, this distance is put tentatively at about 15 knots. Distant orientation was tested in both species; 13 birds out of 15 returned from distances varying from 17 knots to 740 knots.

The work as a whole is mainly of interest in that it demonstrates the possibility of conducting experiments upon the behavior of marine birds.

Alfred G. Mayer continued the study of rhythmical pulsation and found that in *Cassiopea* the stimulus which produces pulsation is maintained by the diffuse nervous system of the subumbrella, and this stimulus causes the muscles to contract. The stimulus will readily pass through tissue which has recently regenerated and contains no muscles, or through parts wherein the muscles have been rendered incapable of contracting through the action of magnesium, distilled water, calcium, carbon dioxide, or alcohol. On the other hand, the pulsation stimulus can not pass through, or be conducted by, muscles from which the epithelial nervous network has been peeled away.

Magnesium has but little effect upon the pulsation-stimulus, but it causes relaxation and inertness in the muscles, and thus it renders the muscle relatively incapable of responding to the nervous stimulus which causes contraction. Magnesium is, however, necessary for sustained pulsation, for without it the muscles come into sustained tetanus of so pronounced a character that the tissue is finally torn into shreds. This muscular tetanus is due to calcium, as has been shown by Loeb. It is the rôle of magnesium to offset this effect of calcium; and thus the pulsating tissue is held in a state intermediate

between that of sustained tetanus, which would be caused by unchecked calcium, and that of inert relaxation, which would be caused by unchecked magnesium.

In 1906, the writer discovered that circuit-shaped strips of subumbrella tissue of *Cassiopea,* without nervous centers, will maintain themselves in sustained pulsation provided a single contraction be once started in the circuit. This same statement is true of circuit-shaped strips cut out of the heart of the loggerhead turtle.

Such constantly sustained single waves of pulsation are not observed in nature because the nervous centers which initiate the pulsation-stimulus are so arranged as to mechanically check and annul each wave of pulsation as soon as it has traversed the tissue. There is, then, an interval of complete rest until a chemical change recurs, permitting the nervous centers to send forth a new pulsation-stimulus. Thus there are special devices in nature to prevent the condition of "closed-circuit pulsation" discovered in 1906.

It is possible that periodic changes in the proportions of calcium and magnesium in solution are a contributory cause of each pulsation-stimulus.

In addition to the research upon pulsation, the writing of a monograph upon the Hydromedusæ of the world was completed. This will be illustrated by numerous outline copies of previously described Medusæ copied by Mr. Carl Kellner, and also by colored drawings made from life by the writer.

The annual breeding swarm of the Atlantic palolo came on July 2 and 3; and the last quarter of the moon fell on July 2, 1907. Experiments indicate that the worms can swarm when tidal rise and fall is obliterated, but that they can not swarm unless moonlight falls upon the coral rocks within which they live.

During the year papers embodying the results of researches carried out at the Tortugas Laboratory have been presented for publication by the following authors:

W. K. Brooks and B. McGlone. The origin of the lung in *Ampullaria.*
W. K. Brooks. The pelagic Tunicata of the Gulf Stream, parts II and III.
W. K. Brooks and Carl Kellner. The pelagic Tunicata of the Gulf Stream, part IV. A new appendicularian from the Dry Tortugas, with notes on its embryology.
Edwin G. Conklin. Two peculiar actinian larvæ from Tortugas, Florida.
R. P. Cowles. Habits, reactions, and associations in *Ocypoda arenaria.*
C. H. Edmondson. A variety of *Anisonema vitrea.*
H. E. Jordan. The relations of the nucleolus to the chromosomes in the primary oocyte of *Asterias forbesii.*
Edwin Linton. Helminth fauna of the Dry Tortugas.
Charles R. Stockard. On the habits, reactions, and mating instincts of the walking-stick, *Aplopus mayeri.*
Charles Zeleny. Some internal factors concerned with the regeneration of the chelæ of the gulf-weed crab (*Portunus sayi*).
A. G. Mayer. Medusæ of the world, vol. I, Hydromedusæ.

Only three researches have been published during the year; these are:

CARL KELLNER, Johns Hopkins University. Bericht über die Embryologie von *Oikopleura*. Zoolog. Anzeiger, Bd. 31, May, 1907.

EDWIN LINTON, Washington and Jefferson College. Note on the habits of *Fierasfer affinis*. American Naturalist, vol. XLI, pp. 1–4, 2 figs., January, 1907.

ALFRED G. MAYER, Carnegie Institution. Rhythmical pulsation in Scyphomedusæ. Carnegie Institution of Washington Publication No. 47, December, 1907.

The Laboratory has suffered through the neglect of certain investigators to complete the writing of their papers long after their observations and experiments have been finished. It is far from my thought to urge undue haste in the publication of research, mindful that science in our country has too often suffered just reproach from this cause; but as the equipment for research becomes more complex and the expense of investigation increases, men of science are coming in increasing measure to be but trustees of the funds through the aid of which their studies are sustained. Discoveries belong not to him who makes them, but to the world, whose support has made their discernment possible. For generations it has been the plea that with greater material means scientific labors would bear greater fruit. All over our land enlightened, philanthropic men are answering this plea, and men of science should seek to justify the hope that their labors may in increasing ratio advance civilization.

In conclusion, it gives me pleasure to acknowledge our debt of gratitude to those whose generous aid has contributed in great measure to the success of the year's work.

To Captain William H. Bechler, U. S. Navy, naval commandant at Key West, without whose kindly interest the station could not have been maintained.

To Mr. William Dutcher, president of the National Association of Audubon Societies, who appointed Professor Watson warden of the gulls upon the Tortugas, thus rendering it possible for him to carry out his experiments upon their nesting habits.

To Sir William Grey-Wilson, governor of the Bahamas, for personal and official courtesies which rendered our expedition to the Bahamas both a pleasure and a success.

DEPARTMENT OF MERIDIAN ASTROMETRY,*

LEWIS BOSS, DIRECTOR.

This report covers the year ending September 30, 1907.

The working staff during this year has consisted of 4 assistants (men) and 7 computers (women), in addition to the Director. Mr. Arthur J. Roy is first assistant. Mr. William B. Varnum is also employed upon the more responsible parts of the work. During the period when the transit-circle is to be used in the southern hemisphere, this staff will necessarily be much enlarged; and the funds arising from the current annual appropriations are now being conserved in order to make provision for the temporarily enlarged expenditure which will then be due to this and other causes.

The most important work of the year has been that which relates to the preparation of the Preliminary General Catalog of 6178 stars, described in the report of this Department for last year (Year Book No. 5, pp. 204–211). Soon after the date of that report the final installment of star-positions determined in 1905–06 at the Royal Observatory of the Cape of Good Hope was received from the Astronomer Royal, Sir David Gill. During the following winter these results, as well as those of the same epoch obtained at the Dudley Observatory for northern stars, were incorporated in the equations of condition for the determination of position and motion for the respective stars, and the final solutions were obtained. At the same time the positions of many of the standard stars were revised where newly published star-catalogs furnished the means for appreciable improvement. As it stands this catalog of 6178 stars includes essentially all the weight of published observations available up to the present time.

For each star of this catalog is given the position and proper-motion for 1900, together with the elements of precession necessary to reduce the positions to other epochs. Furthermore, are also given the mean epoch of observation for each star, the probable error of the position for that epoch and for 1910, as well as the probable error of the annual variation. Thus the Catalog is not only designed to place at the disposal of the reader the most reliable position that it is practicable to compute for a given star at any epoch required, but it aims, also, to afford a good quantitative idea of the degree of confidence to which that position is entitled. This constitutes an innovation upon previous practice and should be of advantage in more than one way. For example, if one should deduce any supposed fact in regard to the mutual relations of any of the proper motions of this Catalog, or in regard to residual systematic motions of the stars, he will be able to form a

* Address: Dudley Observatory, Albany, N. Y. Grants Nos. 368 and 406. $40,000 for study of motion and structure of the stellar system of the northern and southern hemispheres. (For previous reports see Year Book No. 2, p. xviii; Year Book No. 3, p. 85; Year Book No. 4, pp. 78-82; and Year Book No. 5, pp. 204-211.)

fairly approximate idea of the extent to which his conclusions may be affected by the errors arising from observation alone. There can scarcely be two opinions as to the very decided value of such information in nearly all researches for which the Catalog is likely to be employed.

Very great care has been exercised to eliminate as far as possible the mistakes, large and small, that are liable to creep into a work of this kind, where the numbers are collated or formed from many separate series of papers in the original details of computations. The greater part of the energies of the working staff during the last three or four months has been expended in the endeavor to secure, so far as may be, immunity from these possible errors of compilation. All the data for the General Catalog of every name and nature are now collected in a systematic manner upon the catalog-cards and the numbers have all been subjected to repeated examination and tests. From these cards the printer's sheets are to be copied, and that work is now in progress. At its conclusion, in the near future, it is proposed to submit the Preliminary General Catalog for publication.

The formation of the definitive catalog, with its unusually precise values of proper-motion, based upon observations from which the systematic errors to an important extent have been eliminated, offers favorable opportunity for the prosecution of a number of related investigations. Advantage has been taken of this fact to some extent already, and efforts in this direction are likely to continue for some time in the future.

As a supplementary work of this kind the systematic errors and weights of all the star-catalogs produced under the plan of the Astronomische Gesellschaft have been investigated with care. The Preliminary General Catalog affords a very effective means for ascertaining these corrections and weights with a fair degree of precision, so far as stars brighter than eighth magnitude are concerned. With any less extensive and efficient medium of comparison it would not have been practicable to ascertain the systematic corrections for these narrow zones with a satisfactory degree of precision. As the matter now stands a very large mass of valuable observations contained in the Gesellschaft zones and elsewhere has now, for the first time, become really available for use in researches of precision. The results, in condensed form for practical use, will be presented in the introduction to the Catalog.

Certain questions relating to stellar motions have already been tested here since the catalog-cards have been completed. For the vast majority of stars it may be assumed, with sufficient accuracy, that their motions are upon great circles of the sphere with uniform velocity. But in the case of binary stars this assumption may, and sometimes does, so far depart from the truth as to require sensible correction on account of orbital motion, not only for the fainter but also for the brighter star. In order to make this correction in a given instance it is necessary to have precise knowledge both of the orbital elements and of the relative masses of the components of the double star in

question. The computations of double-star orbits are frequently revised, so that there are usually available recently published results based upon nearly all the available observations down to the present. But in the matter of determination of the relative masses for the components of binary systems the conditions are not so favorable. Accordingly, we have determined for ourselves the relative masses of the two components for each binary offering promise of a useful result. The determination of the relative masses from meridian observations is a work of some difficulty in practical application. The observations are liable to peculiar errors, especially in the case of close and unequal pairs. Some of these errors are systematic. Nevertheless, the chief difficulty has always been that of determining the dimensions of a minute orbit from the results of meridian observations, which, except in a few special cases, must be done before the relative masses can be evaluated. The revised, or corrected, observations at our disposal in the present instance have greatly facilitated this work. We have attempted this computation for 12 binary systems. For some of these the evidence is still entirely insufficient to insure a trustworthy result; but in more than half of the cases the determination seems to be entitled to some confidence.

Agreeably with the experience of previous computers, we have found, in general, nearer equality between the masses of the two components of a binary star than might have been inferred from their relative brightness. Thus the principal star of Sirius is about 10,000 times as bright as the companion star, while its mass is only about 2.6 times as great as that of the companion. The principal star of η Cassiopeiæ is about 40 times as bright as the companion, but has a mass only about 1.3 times as great.

On the other hand, previous computers have found numerous instances in which the fainter star of a pair appeared to have much the larger mass. In no case where the basis of determination in our computation could be regarded as at all adequate has the mass of the companion appeared to be materially greater than that of the brighter star. In fact, of all the stars investigated only two, 85 Pegasi and Bradley 3210, come out with a mass for the brighter star of less than 0.9 (that of the fainter star being the unit), and even in these cases the hypothesis of equal masses is not especially repugnant to the observations.

The mass of the sun is more than 1,000 times greater than that of Jupiter, the largest planet; so that when one star of a pair has not more than three times the mass of the other there may be said to be a tendency toward equality of masses. This is the case with the double stars we have investigated; and with existing ideas of stellar evolution it is rather difficult to devise a satisfactory explanation of this prevailing tendency toward equality of masses. It may be easily admitted and explained for an isolated case, or for a proportion of all; but why this near equality should be the rule rather than the exception is more difficult to understand. But if we accept the results of computers who have recently found in several instances that the

mass of the fainter star is very much greater than that of the brighter, we shall find it very much more difficult to account for such a state of things. Our present computations appear to remove the immediate necessity of accepting or accounting for the existence of such an apparent anomaly, and to that extent may be regarded as having performed a useful service. The results will appear in the introduction and notes of the Catalog.

As to proper-motion in general, the fundamental assumption is that the individual star, or separate systems of stars, are in rectilinear motion with uniform velocity. But if this is correct, then the motion of the stars as projected on the sky upon great circles are obviously not rigorously uniform in those circles. Within periods sufficiently limited the angular proper-motion of a star will be uniformly accelerated if the star is approaching the solar system, and the contrary if receding. For any case in nature, however, this foreshortening or perspective effect must be exceedingly minute. Heretofore it has escaped identification. During the present year, however, we have examined the meridian observations of 61 Cygni and Groombridge 1830 to find whether this effect of perspective is now to be recognized in the meridian observations. In both instances the result has been affirmative, though the probable errors of the respective results are nearly as large as the effects determined. When the star's parallax and its motion in the line of sight are known in combination with the proper-motion the variation of the proper-motion on account of this foreshortening effect can be independently computed as a predicted effect. This we have done for the two stars in question, and the results obtained in this manner agree quite satisfactorily with those obtained from the meridian observations. The uncertainties of the computation, however, are necessarily very great in relation to the excessively minute quantities under consideration; yet it may be regarded as an auspicious beginning when it is found possible to bring to bear testimony tending to show that our methods of determining stellar parallax and motion in the line of sight lead to results that are in harmony with measurements of stellar position. Furthermore, it is demonstrable that the precision with which this test can be applied will rapidly increase with time—*i. e.,* in a geometrical ratio.

Still more important is the fact that these computations shed some additional light, however feeble, upon a fundamental hypothesis. Are the motions of the stars sensibly rectilinear? Much evidence in the nature of inference already exists in favor of an affirmative answer to this question. The present computations lead to results resembling evidence of a positive nature. We can now foresee the time when it may be possible to say in reference to several stars not only that their observed motions offer nothing to contradict the hypothesis that the actual stellar paths may be rectilinear, but do afford positive evidence that the curvature can not exceed a certain small and specified limit. The attainment of such evidence would obviously constitute a distinct forward step of fundamental importance.

In a paper read at the Washington meeting of the National Academy of Sciences in April last the proper-motions of our General Catalog were drawn upon for a preliminary test of the hypothesis of random motion among the stars. Four areas of 15° radius, with centers approximately 90° from each other and from the apex of solar motion, containing in all 436 stars, were taken into consideration. The motions of these stars appear very strongly to favor the hypothesis that the direction taken by the motion of any given star or system of stars is purely a matter of chance. It is necessary to modify the statement in this way as to "systems of stars" because many such, in which two or more stars have direction and velocity of motion in common, are known to exist. It would be premature to say that the random motion of stars has been demonstrated through this limited preliminary investigation; the object of the research was simply to gain some indication of probability on this point and an estimate of certain constants to be employed in a tentative investigation of the precession and solar motion. Quite recently we have taken this investigation in hand, basing it upon the proper-motions of the Preliminary General Catalog.

The right-ascensions of the new catalog are freed from the effect of personal equation dependent on magnitude, and further evidence has been obtained that the elimination of this error has been practically effective.

A portion of the staff has been engaged in preparation of the observing lists both for the northern and southern hemispheres. Associated with this work, in a labor-saving way, is the preparation in our usual manner of ephemerides of the stars to be corrected by observation. This work is progressing well.

Progress has also been effected in the final compilation of the Albany observations, 1896–1900, into catalog form. Hitherto we have drawn upon these observations as they have been required for the Preliminary General Catalog; now we are forming the definitive catalog of about 10,000 stars, mostly situated between the parallels of —21° and —37° of declination, for the more extensive use required in the construction of our larger General Catalog. It will also serve an important purpose as a connecting link between our projected observations to be made in the northern and southern hemispheres.

Operations relative to the new series of observations to be undertaken here in connection with subsequent observations to be made in the southern hemisphere have been initiated. These afford much encouragement in regard to the efficiency of our transit-circle. It appears that we have no really serious anomalies to fear in the use of this instrument. Thus we have, in advance, assurances in regard to the reliability of our instrument similar to those which have proved so advantageous in important series of fundamental observations like those undertaken at Pulkowa, Greenwich, and the Cape of Good Hope. This advantage is due, of course, simply to the long-continued

use of the instrument, to the improvements introduced, and to the successive and laborious efforts made to correct its indications for unavoidable errors of construction or action.

During the year a clock of precision by Clemens Riefler, of Munich, has been purchased and set up in order to increase, if possible, the precision of the right-ascensions determined with the transit-circle, especially as to periodic errors that may be induced by diurnal change of atmospheric pressure and temperature. This form of clock has a nickel-steel pendulum in an air-tight case exhausted to a partial vacuum.

In general, preparation for the proposed observations in the southern hemisphere have been continued, but at present these do not appear to require any special comment.

NUTRITION LABORATORY,*

F. G. Benedict, Director.

The researches into human nutrition which have been carried out by grants from the Carnegie Institution of Washington in the chemical laboratory of Wesleyan University, at Middletown, Connecticut, began with a study of the influence of inanition on metabolism. Though innumerable new problems arose out of this interesting research, the particular form of apparatus then in use was not specifically designed for studying these correlated problems, and hence the important question as to the general influence of the ingestion of food upon metabolism was next studied.

The classical researches of Rubner on the one hand and Zuntz and his associates on the other have brought to light much interesting data regarding the influence of the ingestion of food upon metabolism, the digestive processes, such as the secretion of digestive juices and the activity of peristalsis, with special reference to the effect upon the heat production and the gaseous exchange in the lungs. The methods employed by these investigators were markedly different, and hence it is not surprising that noticeable differences in the nature and extent of the various phenomena have been reported by the two schools.

The respiration calorimeter, designed as it is to measure simultaneously the carbon dioxide, water-vapor and heat elimination and the oxygen consumption of a man, is especially well adapted to the study of the phenomena incidental to the ingestion of food, and consequently an extensive series of experiments have been made with the view of obtaining new information on this most important physiological process.

In such experiments it is necessary to have a "base-line" or standard of comparison to which the various activities may be referred, and by common consent all physiologists have taken for this standard the physiological activity of the body at rest and after a short period of fasting. The importance of knowing more fully the exact nature of metabolism during inanition led to an extended series of observations on fasting men, in which the period of inanition continued from 2 to 7 days. The results of these observations have been published by the Institution as Publication No. 77.

Physiologists, in considering a diet, are wont to recognize not so much the kinds and amounts of food materials ingested as the kinds and amounts of the nutrients contained in the food materials. These nutrients—the protein, fat, and carbohydrate—exist in all food materials in varying amounts, the flesh foods being rich in protein and fat, while as a rule the vegetable foods furnish the greater supply of carbohydrate, such as starch and sugar. Protein and fat of vegetable nature, such as gluten of wheat and olive oil, are,

* Situated at Boston, Massachusetts. Grant No. 352. $100,000 for purchase of site and construction of building, and for investigations. (For previous reports on work in nutrition see Year Book No. 2, p. xxxix; Year Book No. 3, p. 130; Year Book No. 4, p. 258; and Year Book No. 5, pp. 212–219.)

however, invariably found in the ordinary mixed diets. Olive oil as a pure fat and cane-sugar as a pure carbohydrate and other similar materials are used to a certain extent in our diets, but usually the nutrients are mixed in varying proportions, dependent upon the nature of the food and the dietetic habits of people. Pure protein is almost never eaten, as it is difficult to prepare in large quantities.

Experiments on the influence of the ingestion of food soon showed that there were marked differences in the effect of the different nutrients on the general metabolism. When relatively pure protein was ingested it was followed by a considerably greater increase in the bodily activities than was the ingestion of an equal quantity of pure carbohydrate or fat. So great was this apparent stimulus to metabolism that Rubner first considered it a "specific dynamic" action of protein. Zuntz has found a similar stimulus to metabolic activity, though of less intensity, in the case of the other two nutrients. Few of the experiments made by these investigators were conducted upon men, and in attempting to study the fundamental laws governing metabolism in man it is obviously desirable to institute an extended series of experiments to study the influence of the ingestion of food upon metabolism. The experiments were planned to include a study not only of the effect of the ingestion of varying amounts of the ordinary mixed diets, but also a study of the influence of ingesting varying amounts of relatively pure nutrients.

While as has been shown by the long series of experiments on inanition the true fasting metabolism is not reached till the second or third day of a fast, for purposes of comparison, at least at the present stage of the development of the experimental technique, the metabolism during rest, 12 hours after the last meal (which is usually a very light one), is reasonably constant with the majority of subjects. Consequently our experiments are planned as follows: The evening before the experiment begins the subject is given a very light supper. The next morning at 7 he enters the chamber of the respiration calorimeter, sits comfortably in an arm chair and reads. About an hour is required to adjust the heat-measuring devices and secure thermal equilibrium in the chamber. An unbroken series of four 2-hour experiments then follows. Without leaving the arm chair the subject is weighed accurately at the beginning and end of each period. By means of a pneumograph the pulse and respiration rates are recorded. An electrical thermometer permits the observation of the rectal temperature of the subject as often as desired (usually every 4 minutes), and there are measured simultaneously the carbon dioxide and water-vapor output, the heat production, and the oxygen consumption. The four 2-hour experiments usually show a remarkable agreement, thus attesting to the uniformity of the metabolism under these conditions. Duplicate experiments made with the same subject after several intervening weeks or months likewise show uniformity. Thus the standard of comparison may be said to be well established.

When the effect of the ingestion of a specific nutrient or article of diet is to be studied, the plan of the experiment is altered in only one particular—*i. e.*, immediately after entering the respiration chamber the subject is requested to eat as much as possible of the material to be studied. The food is usually consumed in a few minutes without unusual muscular effort, and as soon as the calorimeter is in temperature equilibrium the series of 2-hour observations begins. Generally four 2-hour periods constitute an experiment, though at times the observations may be continued for 12 to 15 hours, due care being taken in all cases not to fatigue the subject with the long-enforced muscular rest. The various measured factors can then be compared with those obtained under the conditions of fasting.

Obviously, according to this plan it is possible to determine with considerable accuracy the effect of the ingestion of varying amounts of nutrients upon body weight and temperature, pulse and respiration rate, the elimination of carbon dioxide and water-vapor, the consumption of oxygen, and the heat production, and thus throw important light on the question of the work of digestion.

The experiments are still in progress and the results of those already made have not been wholly computed; hence any detailed discussion would be premature, but it may be said that the ingestion of food of any kind results in an increased metabolism as shown by the measurements of the factors mentioned above. Marked differences in the effect of the ingestion of protein fat or carbohydrate are also noted.

The nature of the increase in metabolic activity is not yet wholly clear. Probably all the various factors, such as increased motility of the digestive tract, glandular activity in secreting digestive juices, the chemical action of ferments in inducing hydrolysis, etc., contribute to the total effect. Certainly innumerable problems of vital interest to the physiologist as well as the physician await study.

During the past year two 24-hour experiments and forty-three 8-hour experiments, all with healthy men, were made. These experiments supplement the work of the previous year, and while the subject has not as yet been adequately studied, the research must necessarily be interrupted for a few months until the apparatus in the new laboratory is constructed and tested.

The investigations the past year have been somewhat hampered by the innumerable details incidental to closing out the experimental work in the chemical laboratory of Wesleyan University at Middletown, where it has been in progress for many years, formerly under the direction of Prof. W. O. Atwater and in late years under my direction. The research has been fostered by the U. S. Department of Agriculture, the Connecticut (Storrs) Experiment Station, Wesleyan University, and in recent years liberal grants from the Carnegie Institution of Washington have made possible a large amount

of other research. To bring to a close the academic work at Wesleyan University and the experimental work for the Department of Agriculture necessitated a radical change in plans, the writing of many uncompleted reports, and the summarizing of all accumulated data.

In accordance with my suggestion of last year, which was indorsed by the Board of Trustees of the Institution, I took occasion, during the winter months, to visit a number of American universities where research in nutrition was in progress, and in March last left for an extended tour of the European laboratories. The objects of these visits were to obtain suggestions regarding the construction and equipment of the new nutrition laboratory, to become more familiar with existing research in nutrition, and to bring the most eminent American and foreign specialists into touch with the object and plans of the nutrition laboratory. Incidentally opportunity was taken to explain more fully to physiologists and physiological chemists the work of the Institution.

The establishment of a nutrition laboratory by the Institution was conceded by all to be a most valuable undertaking, and the most hearty assurances of cooperation were given.

I wish here to express my sincere thanks for the unfailing courtesy accorded me by the directors of the many laboratories it was my privilege to visit.

The amount of editorial work the past year has been unusually large, as the proof-reading of the report on inanition is just being completed as this is written.

After the vote of the Board of Trustees of the Institution to establish the nutrition laboratory I accompanied President Woodward on a tour of inspection of possible laboratory sites. After a most searching examination of a number of locations and a comparison of climatic and pecuniary advantages, the recommendation was made (and concurred in by the Executive Committee) that a site on Vila street, Boston, was in our judgment best suited on the whole to the present and future needs of the laboratory.

Tentative plans for a building had been prepared some time before, and immediately upon the securing of the site a firm of architects was employed to work out the many engineering details. It is believed that the building will be ready for occupancy February 1, 1908. During my foreign tour opportunity was taken to purchase a considerable amount of apparatus of special design for use in the new laboratory.

The plans for the coming year contemplate the computation of the results of the experiments of 1906–07, the equipment of the new laboratory, and the construction of one or more respiration calorimeters for use therein.

MOUNT WILSON SOLAR OBSERVATORY,*

GEORGE E. HALE, DIRECTOR.

Current views of solar phenomena are based on the assumption that light from all parts of the sun's disk reaches us along nearly straight lines. So far as white light is concerned this assumption may be warranted, if, as is generally believed, the pressure of the solar atmosphere is low. But in the case of monochromatic light, differing but slightly in wave-length from any of the dark lines of the solar spectrum, the influence of anomalous dispersion should be taken into account. In its passage through the gases and metallic vapors of the solar atmosphere, such light must deviate from a straight path by an amount which depends upon the density gradient of the vapor producing the corresponding Fraunhofer line. Even for slight density gradients, smaller than those ordinarily assumed to exist in the chromosphere and reversing layer, the effects of anomalous dispersion have been found by laboratory experiments to be very striking indeed. We must therefore seek to determine in what degree our interpretations of solar phenomena require modification in the light of this principle.

We are indebted to Professor Julius, of the University of Utrecht, for a series of important papers, in which many of the possible applications of anomalous dispersion to solar theory are set forth in detail. According to his views, which are based upon laboratory investigations, the chromosphere and prominences do not exist as they appear to us; the bright lines of their spectra are not the radiations of luminous gases, but photospheric light brought into our line of vision after anomalous refraction through non-homogeneous gases. Such effects, when imitated experimentally in the laboratory, are very striking. But astronomers are not yet ready to admit that chromosphere and prominences, faculæ and flocculi, and other phenomena long universally held to have objective existence, are simply due to anomalous ray-curving. They demand far more evidence than has yet been supplied. Physicists, on the other hand, are more favorable to Professor Julius's views. Unhampered by that impelling belief in solar phenomena which results from decades of observation, they ask how the phenomena of anomalous dispersion can possibly be absent, under conditions admittedly so favorable for their manifestation.

It was thus a fortunate circumstance that permitted Professor Julius to spend some weeks on Mount Wilson during the past summer. His laboratory in Utrecht is devoted entirely to physical work, and is not equipped for solar investigations. For this reason our collection of solar photographs, and the opportunity to use the spectroheliograph and other instruments, was

* Situated on Mount Wilson, California. Grant No. 403. $85,000 for construction, investigations, and maintenance. (For previous reports see Year Book No. 3, pp. 154–174; Year Book No. 4, pp. 56–77; and Year Book No. 5, pp. 60–86.)

precisely what he required. The principal advantage of his visit, however, was to familiarize us with the phenomena of anomalous dispersion, and to bring out, in a series of discussions, many suggestions required in the formulation of a general attack on the question, which must be made here, in immediate connection with the solar work.

In preparing for this attack I have borne in mind the requirements of several closely correlated lines of research. Our interpretation of sun-spot spectra has advanced rapidly during the year. The hypothesis that the strengthening and weakening of solar lines in spots is due to reduced temperature has received support from several sources. Chief among these are the results of laboratory studies of spectra corresponding to various temperatures, the discovery in spot spectra of bands due to compounds which may not exist at the higher temperature of the photosphere, and the strengthening of spot lines in the red stars. It is nevertheless true that certain phenomena can not be accounted for by this hypothesis, and our minds must be open to the possibility that anomalous dispersion plays some part in producing the widened lines. In the hope that it would assist in the interpretation of spot spectra, we have made a comparative photographic study of the spectra of various parts of the sun's disk. We found, to our surprise, that near the limb the spectrum exhibits very marked changes, not only in the relative intensities of the lines, but also in their positions. While the results so far obtained suggest that a difference in effective pressure may be the principal cause of the displacements, it is by no means impossible that anomalous dispersion may play a principal or a minor part. When we also consider the diverse and complex problems encountered in the interpretation of the spectroheliograph results, we perceive that nothing short of an extensive series of laboratory investigations, involving the comparative study of the temperature, pressure, and anomalous dispersion changes of a selected list of solar lines, must be made in conjunction with a parallel study of the same lines in the sun and stars.

In such work we are concerned with purely physical questions, which underlie the interpretation of solar and stellar phenomena. Let us now consider a very different phase of the problem of stellar evolution. Thanks to the labors of such men as Gill, Boss, Campbell, and Kapteyn, rapid progress is being made in our knowledge of the structure of the sidereal universe.* The closeness of the bond that unites the astronomy of position with astrophysics is well illustrated here, for one of the greatest of present needs is the determination of the velocities of motion in the line of sight of a very large number of stars. These spectrographic results would settle the question of the sun's motion in space, add greatly to our knowledge of the two

* Ably summarized by Sir David Gill in his recent address as president of the British Association.

groups or streams into which Kapteyn and Eddington have separated the stars, and contribute in other important ways to the solution of the problem of sidereal distribution. The photographs would also serve, quite as well as though made with no other end in view, for the study of stellar evolution.

This possibility illustrates the mutual advantages of the arrangement I have recently concluded with Professor Kapteyn. Astronomers are well acquainted with his remarkable work, not only in the solution of cosmical problems, but in organizing a cooperative attack involving the use, for a common end, of telescopes in many parts of the world. Since faint stars, as well as bright ones, must be included in any investigation of the general laws of stellar distribution, it is evident that an attempt to cover the entire sky, which would involve the minute study of many millions of stars, is out of the question, at least within any reasonable period of time.

Accordingly, Kapteyn has selected a certain number of areas, uniformly distributed over the heavens. The brightness, proper motion, parallax, spectral type, and radial velocity of all stars within these areas will be determined, through the joint efforts of many observatories. There has been little difficulty in providing for the work on the bright stars, but the instrumental means available do not suffice for the fainter ones. For this reason I have long felt that the large reflecting telescopes of this Observatory should provide some of the necessary observations of the fainter stars, if this could be done in such a way as to contribute effectively toward the solution of our own problem of stellar evolution.

During the past year I have devoted much time to the preparation of a working program for our 60-inch reflector. Since all the lines of research with this instrument should converge on our principal problem, cooperation with Professor Kapteyn, who is concerned with the very different question of stellar distribution, might appear to be excluded. A single illustration will show, however, that this is not the case. Kapteyn believes that the stars of the Hyades may belong to a true physical system, since their proper motions, and probably their parallaxes, are in good general agreement. Hitherto, however, he has been unable to find whether their radial velocities also correspond, since no large telescope could be employed to measure them. Should the 60-inch reflector prove them to do so, a common origin may with confidence be assigned to the group. If these stars could be shown to have commenced their evolutional career at the same period and under similar conditions, a minute study of their spectra might throw light on the possible relationship between a star's mass and its spectral type—a question of fundamental importance. In many such cases the measurement of radial velocities, parallaxes, and stellar magnitudes will be essential in connection with our spectroscopic work. The Solar Observatory is neither a physical laboratory nor an observatory for the study of the astronomy of position. Experience has shown, however, that it can not depend upon other institu-

tions to furnish all the data required in the solution of its own problems. Furthermore, the value to physics or astronomy of the results it may attain in these fields will be increased by their correlation with astrophysical phenomena.

It is expected that Professor Kapteyn will spend a portion of each year with us, and have charge of such parallax and similar work as may be done with the large reflectors. Although these instruments must be devoted, for the most part, to spectrographic observations and the photography of nebulæ, I believe that they may also yield important contributions to Kapteyn's cooperative undertaking.

STAFF.

Throughout the year Mr. W. S. Adams has remained in charge of the computing division, while Mr. G. W. Ritchey has continued his work as superintendent of construction. Dr. Henry G. Gale, who spent a portion of last year on Mount Wilson, returned to the University of Chicago in September, 1906. Mr. Ferdinand Ellerman, assisted occasionally by Dr. Charles M. Olmsted, has continued to take the daily series of photographs with the Snow telescope and the 5-foot spectroheliograph. He has also made various photographs of sun-spot spectra, and has done much general photographic work. Mr. Olmsted has spent most of his time in laboratory investigations, but has also made a series of pyrheliometric observations in continuation of Mr. Abbot's work on Mount Wilson. Dr. H. K. Palmer, who was engaged in bolographic investigations with the Snow telescope during the summer of 1906, resigned his position in September. Miss Louise Ware and Miss Ruth E. Smith have continued their work in the computing division. Miss Jennie B. Lasby and Miss Cora G. Burwell were appointed computers in October, 1906, and July, 1907, respectively.

Prof. W. H. Julius, of the University of Utrecht, was engaged in special investigations on Mount Wilson during the summer of 1907.

INVESTIGATIONS IN PROGRESS.

The investigations in progress during the past year include: (1) Daily photography of the sun with the photoheliograph; (2) daily photography of the sun with the spectroheliograph; (3) photography of the spectra of sun-spots; (4) photographic comparisons of the spectra of various parts of the sun's disk; (5) spectrographic investigations of the solar rotation; (6) laboratory investigations; (7) pyrheliometric observations; (8) magnetic observations with a recording variometer.

No important modifications have been made in the Snow telescope, except that it has been found advantageous to blow all of the mirrors with electric fans, during the exposures with the spectroheliograph, to prevent distortion and change of focal length.

Direct Photography of the Sun.—Mr. Ellerman or Mr. Olmsted have made direct photographs of the sun daily, with the Snow telescope, on a scale of 6.7 inches to the diameter. As these negatives have proved very useful in connection with the study of spectroheliograph plates, this series of photographs will be continued.

Work with the Spectroheliograph.—The 5-foot spectroheliograph has continued to give excellent results and has required no modifications of any kind. The daily series of photographs comprises negatives made with the lines of calcium, hydrogen, and iron.

I have also devised a simple attachment for the spectroheliograph, to be used in a determination of the level of sun-spots. It will be remembered that in the last discussion of this subject it was pointed out that sun-spots are probably of higher level than the photosphere, since their heat radiation falls off less rapidly than that of the adjoining photosphere when the spots approach the limb. In our studies of spot spectra, however, we found that the spot radiation contains a larger proportion of the less refrangible rays than the photospheric radiation. It might therefore be expected that even if the spots were at the level of the photosphere, and subject to the same absorption, they would fall off less rapidly in intensity near the limb. It is evident that in order to test the question monochromatic light should be used. As the spectroheliograph offers the simplest means of obtaining monochromatic images, using light from the continuous spectrum at any desired wave-length, it was decided to employ it in preference to bolometric or other heat-measuring apparatus, particularly as it should permit smaller spots to be investigated. There appears to be only one difficulty in the use of the instrument for this purpose, arising from the fact that the umbra requires from six to ten times the exposure needed for the photosphere (for yellow light), in order to get approximately equal density on the plate. This can be easily overcome by the use of a screen of dark glass, through which the photosphere is photographed. Two small plates of dark glass are mounted on the collimator slit of the spectroheliograph in such a way that the spot is included between their beveled edges, while the light from the neighboring photosphere is reduced in intensity by the glass. The distance between the plates can be varied, so as to permit their use with spots of various sizes. The intensity of the spot and that of the neighboring photosphere (reduced by a known amount) are measured with a Hartmann photometer. It is hoped that in this way any change in the relative radiation of spot and photosphere can be determined with considerable accuracy. The photographs are being made with the camera slit set on the continuous spectrum in a region free from lines. This wave-length is chosen in preference to a point in the blue or violet, since the effect of scattered light from the sun and sky would be much more serious in the more refrangible region.

In the measurement of heliographic positions, the heliomicrometer has continued to give excellent results, described elsewhere in this report. In the comparative study of the minute details of the flocculi, experience has shown that the most satisfactory results can not be expected until the 30-foot spectroheliograph becomes available for this work. Small atmospheric disturbances, though hardly sufficient to affect the sharpness of the photographs, produce slight irregular displacements of details which are rendered appreciable by the stereo-comparator when the monocular attachment is employed. While these displacements do not interfere with the general comparison of hydrogen and calcium flocculi, for example, they are objectionable when the relative positions of minute details are to be studied micrometrically. Such difficulties should entirely disappear when the 30-foot spectroheliograph of the tower telescope is employed, since in this instrument two photographs can be taken simultaneously in different lines.

The construction of the 30-foot spectroheliograph of the tower telescope has been postponed until the difficulties encountered in securing suitable prisms can be overcome. Experiments made by Zeiss and Mantois have failed to yield large prisms of glass sufficiently homogeneous to give good definition. It has therefore become necessary to try experiments with fluid prisms, which promise some hope of ultimate success.

Meanwhile the 30-foot Littrow spectrograph of the tower telescope has been provided with an attachment which will permit it to be used as a spectroheliograph. This was not done until experiments with a temporary spectroheliograph, described in Contributions from the Solar Observatory No. 7, proved that an auto-collimating instrument, containing a grating, was capable of yielding good results with the narrower dark lines of the spectrum.

Hitherto all discussions of spectroheliographic results have been based on the hypothesis that the flocculi are masses of luminous and absorbing vapors lying above the photosphere. While this hypothesis seems to be in good agreement with the observed phenomena, we must not overlook the possibility that it does not correctly represent the facts. Monochromatic photographs of the sun are made under conditions which are most favorable for the registration of any effects that may be due to anomalous dispersion. In the experiments made on Mount Wilson by Professor Julius, and described elsewhere in this report, the 5-foot spectroheliograph was employed to photograph the sodium vapor within a tube through which sunlight was transmitted. Slight inequalities in density, produced by blowing a current of air through a tube surrounded by the vapor, were easily recorded by the spectroheliograph. In our ordinary assumptions regarding the condition of the calcium vapor in the sun we consider density gradients, exceeding those in Professor Julius's sodium tube, to be present. It is, therefore, very probable that anomalous dispersion phenomena may affect, if they do not alto-

gether determine, the records of the spectroheliograph. This subject will be given the most careful consideration during the coming year, and efforts will be made to ascertain, by experiments devised for the purpose, whether or not we actually observe in the flocculi the effects of anomalous dispersion.

Spectra of Sun-spots.—The inquiry into the cause of the characteristic phenomena of sun-spot spectra, which was described in my last report, has been continued during the year. It may be stated that the large amount of evidence which has been brought together is decidedly favorable to the hypothesis that reduced temperature of the spot vapors is the principal factor in determining the relative intensities of the spectral lines, though no final conclusions may be drawn until the possibility of accounting for the phenomena on other grounds has been thoroughly tested. The pressure of other work has hitherto prevented us from building an electric furnace capable of giving much higher temperatures than the one previously employed, but it is hoped that such a furnace, so devised as to be suitable also for investigations on anomalous dispersion, will soon be ready for use. The investigation of the cause of the spectroscopic phenomena of spots, which has hitherto been confined mainly to the possible effects of temperature and pressure of the vapors, will now be extended so as to include the influence, if any, of anomalous dispersion.

Our detection of several of the flutings of titanium oxide in spot spectra, and Professor Fowler's discovery that some of the flutings shown in our photographic map of the spot spectrum are due to magnesium hydride, are precisely what might be expected on the basis of our temperature hypothesis. The titanium oxide flutings do not appear to be present in the solar spectrum away from spots, but the lines of the magnesium hydride fluting seem to be faintly apparent. If reduced temperature is to be considered as the prime cause for the strengthening of these lines in spots, it becomes necessary to explain how they can be produced, even faintly, in the solar spectrum. On the one hand, it might be assumed that the temperature at some distance above the photosphere is sufficiently low to permit hydrogen and magnesium to combine. This is probably not the case, however, since bright lines of this fluting have not, to my knowledge, been photographed in the flash-spectrum. On the other hand, it might be assumed that the minute dark pores which dot the surface of the sun between the granules consist of comparatively cool vapors, which would give a spectrum analogous to that of spots. We have no observational evidence to support this view; in fact, the observed differences between the solar spectrum at the sun's center and near the limb are perhaps to be considered as opposing it. For the present, therefore, we must regard the hypothesis of reduced temperature in spots as purely tentative, requiring the most rigorous tests that can be devised.

During the spring Mr. Ellerman made from our negatives a preliminary photographic map of the spot spectrum, extending from λ 4600 to λ 7200. The map consists of 26 strips, each including 100 Ångströms, and is provided with a solar spectrum for comparison purposes and an approximate scale to aid in the identification of spot lines. At the recent Paris meeting of the International Union for Cooperation in Solar Research this map, which is the first photographic representation of a large extent of the spot spectrum, was adopted for the use of the cooperating observers. Each visual observer will select a certain limited region of the spot spectrum and compare the lines, as seen at the telescope, with those recorded on the map. In this way any changes in the relative intensities of the lines, if such occur, can be readily detected. Copies of the map have been placed in the hands of all observers who are cooperating in this work. Mr. Adams is engaged in extensive studies of the photographs, for the purpose of drawing up a definitive list of the weakened and strengthened lines. It is hoped that the 30-foot Littrow spectroheliograph of the tower telescope will permit still better photographs to be obtained for use in this investigation.

Since the Snow telescope is not well adapted for stellar work, further investigations of stellar spectra have been deferred until the completion of the 60-inch reflector. It is evident that our discovery in sun-spots of the titanium oxide flutings, which form the most conspicuous feature of the spectra of the red stars of Secchi's third type, will suggest further inquiries into the relationship between stellar and sun-spot spectra. In this connection it is interesting to note that Mr. Newall has already found the red fluting of titanium oxide (shown in our spot photographs) in the spectrum of α Orionis.

Photographic Comparisons of the Spectra of Various Parts of the Sun's Disk.—In endeavoring to interpret the spectra of sun-spots, it seemed advisable to determine photographically whether the solar spectrum undergoes any changes in passing from the center of the sun to the limb. The literature of the subject showed that little had been done in this field, with the exception of the early visual observations of Hastings and the recent visual work of Halm, who found that certain lines, when measured near the sun's limb, were slightly shifted toward the red, as compared with their position at the sun's center. We were therefore wholly unprepared to find such remarkable changes in the appearances of the solar spectrum as our photographs recorded. The principal changes in the solar spectrum, when observed at points very near the limb, may be summarized as follows:

(1) Most of the lines that are strengthened in sun-spots are strengthened near the sun's limb.
(2) Most of the lines that are weakened in sun-spots are weakened near the limb.

(3) Winged lines change greatly in appearance, the wings being much reduced near the limb.
(4) Most of the lines in the spectrum are slightly widened near the limb.
(5) The ultra-violet cyanogen fluting is decidedly decreased in intensity, while the blue carbon fluting is not affected in the same degree.
(6) Most of the metallic lines are shifted toward the red, with respect to their position at the center of the sun.
(7) The shift is not due to ascending currents at the center of the sun, as is shown by measures upon plates taken with the arc spectrum for comparison.
(8) The amount of the shift varies for different lines of the same element.
(9) The cyanogen fluting is not shifted from its normal position.

Other changes might be mentioned, but these are among the most characteristic. It now seems probable that the phenomena can not be attributed to any single cause, and that considerable work will be required to arrive at a plausible explanation of the results. As mentioned elsewhere in this report, a series of laboratory investigations will soon be undertaken on a list of lines whose behavior is being studied in sun-spots and near the sun's limb.

Spectrographic Investigations of the Solar Rotation.—Mr. Adams's photographic investigation of the rotation of the sun by the spectroscopic method has been continued during the year, and the results obtained are now being put into definitive form for publication. The region of the spectrum selected for this work lies in the violet, with its center near λ 4250, and all of the photographs have been taken in the fourth order of the 18-foot Littrow spectrograph. A total of 41 plates has been measured, each containing 6 exposures, which correspond to separate latitudes upon the sun's surface. The larger part of the work of measurement has been done by Miss Lasby of the computing division. Since 20 lines have been measured upon each exposure, the labor has necessarily been great. A short summary of the results is given below. Both the velocities and the daily angular motions are reduced to the sidereal period.

Φ	No. of plates.	Velocity per second.	Daily angular motion.	Φ	No. of plates.	Velocity per second.	Daily angular motion.
°		*Kilometers.*	°	°		*Kilometers.*	°
0.2	21	2.08	14.7	44.7	23	1.28	12.8
7.7	15	2.02	14.5	52.7	18	1.06	12.4
15.0	23	1.96	14.4	59.6	24	0.86	12.1
22.7	13	1.81	13.9	65.7	20	0.70	12.0
29.7	24	1.67	13.7	74.9	33	0.43	11.8
37.7	15	1.46	13.1	80.4	11	0.28	11.8

The more important conclusions derived from the investigation may be summarized as follows:

(1) The period of rotation agrees closely with that of Dunér as far as latitude 50°. In higher latitudes it is considerably shorter. It does not agree with either of the determinations of Halm, but coincides well with their mean.
(2) Different lines give slightly different rotation periods. Of the elements investigated carbon and lanthanum give the longest periods. At the equator this difference amounts to about 0.1° in the daily angular motion.
(3) No appreciable change in the rotation period has been found during the 14 months covered by the observations.
(4) The photographic method gives results for individual lines of slightly higher accuracy than the visual, if we may judge from a comparison of the probable errors. The greatest advantage it possesses, however, is the opportunity it affords for the inclusion of many more lines than would be possible with visual measures.

The work will be continued with the more powerful apparatus of the tower telescope, and it is expected that a higher degree of accuracy can be attained.

Laboratory Investigations.—The electric-furnace investigations mentioned in the last report were carried as far as the available means permitted. It was found possible to obtain the radiation spectra of iron, manganese, and other metals having comparatively low melting-points, with results in perfect harmony with those previously derived from the study of the flame of the arc. Titanium and vanadium, however, could not be volatilized within the carbon tube of the furnace, nor could the temperature be raised sufficiently to produce an iron spectrum corresponding with that of the core of the arc. In the light of our previous experience, and with the further information now available, it is expected that a much more efficient furnace can be readily constructed. This is being designed for the quantitative investigation of the anomalous dispersion phenomena of the more refractory metals and for experiments with various gases at high and low pressures.

A large number of photographs of metallic spectra, corresponding to the core and the flame of the arc, were made by Mr. Gale and Mr. Olmsted. These have been used by Mr. Adams in a study of the relative intensities of the lines for comparison with sun-spot results.

Mr. Olmsted has devoted much of his time to a photographic investigation of the relation between the nature of the discharge of an electric spark and the relative intensities of its spectral lines. The work was done in the Pasadena laboratory, where a 5-kilowatt transformer, giving as high as 66,000 volts, is supplied with a 110-volt alternating current from the Edison Company's system. Mirrors were so mounted that beams from the spark

under observation could be simultaneously directed to the slit of a Littrow grating spectrograph, of 18 feet focal length, and to the slit of a rotating-mirror apparatus for measuring the frequency of the spark.

The investigation was made with two principal objects in view: First, plates have been taken of the titanium spark under various conditions of inductance, capacity, potential, relative length of first and second spark, and with and without air-blast, for the purpose of getting accurate knowledge of the amount of variation which the lines undergo. Second, photographs of the spectra of the sun-spot metals titanium, vanadium, iron, chromium, manganese, nickel, cobalt, and magnesium, extending from the yellow to about λ 3600, have been made for the purpose of obtaining an accurate measure of the relative enhancement of the lines of these metals. These plates contrast the spectrum of the comparatively unimpeded condensed spark of high frequency with that of the impeded spark of a frequency about 75 times slower, the changed frequency being produced by a variation of inductance alone. The intensities of the lines were measured with a Hartmann photometer, in which a wedge cut from the plate to be measured, and formed by a penumbral method, is employed. The curve of these wedges, which is a straight line, is checked or calibrated by a standard intensity interval and a number of intervals of varying intensity photographed on the same plate. As the result of a preliminary measurement of some titanium spectra, it appears that changes of any nature in the discharge circuit which increase the instantaneous current at the moment of discharge increase the relative intensities of the spark lines. If the inductance is varied, all other factors remaining constant, it is found that the intensities of all lines hitherto investigated vary approximately in direct proportion to the frequency of the spark. The frequencies are accurately compared with one another by means of a device which mechanically throws into the discharge circuit, for an instant, a standard inductance. The accuracy with which the relative intensities of the lines can be measured for any given condition of the spark, as determined for a comparison of various photographs taken with different exposure times, is about $\pm$ 2.5 per cent, when the light from various parts of the spark is integrated by means of a ground-glass screen before the slit. The method of measurement with the wide slit employed (0.008 inch) is convenient and sufficiently accurate, since various settings on well-separated lines generally agree to within less than 0.5 per cent.

Pyrheliometric Observations.—The duties of the Smithsonian Astrophysical Observatory in Washington prevented the continuation of the Smithsonian Expedition's work on Mount Wilson during the summer of 1907. At Mr. Abbot's request, however, a pyrheliometer was used by Mr. Olmsted on many days during the winter, spring, and summer, for the purpose of determining the solar constant, on the assumption that the correction derived from the Smithsonian Expedition's observations in 1905-6 can be

applied to these results. This assumption is presumably valid, for it appears from Mr. Abbot's discussion of the bolometric results for 1906, that they can be duplicated from pyrheliometric and relative-humidity observations with an average deviation for a single observation of 1.5 per cent.

Mr. Abbot has furnished a report on the work of 1905-06 (see pp. 152-153), from which it will be seen that results of great value were obtained.

Magnetic Observations with a Recording Variometer.—It does not seem likely that material advantage will result from the continuance of variometer records on Mount Wilson. The variometer was originally provided for the purpose of noting any eruptive solar phenomena that might occur at times of magnetic disturbance. No such connection has been detected, and it therefore seems probable that the correlated study of magnetic and solar phenomena can best be effected with the aid of records obtained at a permanent magnetic observatory, farther removed from electrical machinery than is possible on the summit of Mount Wilson.

Special Investigations.—Professor Julius's work on Mount Wilson consisted mainly of photographic studies, with the 5-foot spectroheliograph, of the anomalous dispersion of sodium vapor in an electric furnace. When the pressure of the vapor in a tube heated by the furnace is reduced, and the conditions so adjusted as to render the vapor as homogeneous as possible, the D lines in transmitted sunlight retain their normal appearance. The large tube which contains the sodium is traversed by two small longitudinal tubes, through either of which a current of air can be forced. The density gradient thus produced gives rise to strengthened dark wings of the D lines, the position of which, to the red or violet, is determined by the sense of the asymmetry in the illuminating sunlight. An image of the interior of the tube, formed on the slit of the spectroheliograph, permits a photograph to be taken, which shows the redistribution of light in the space between the two small tubes, as defined by the direction and magnitude of the density gradient. A series of such photographs will soon be published in one of the Contributions. Asymmetrical illumination may be secured near a sunspot, from the edge of which photospheric light reaches us after transmission through calcium and other vapors where density gradients doubtless exist. It should be possible to learn whether the H_1 flocculi are the effects of anomalous dispersion by photographing a spot group with the camera-slit set on H_1. If photographs of the same group are taken simultaneously with the same spectroheliograph, having a second camera-slit set on the continuous spectrum, the distance between the edges of two spots should, in general, differ in the photographs. If any differences exist, they should increase as the camera-slit is set nearer H_1. Furthermore, photographs made with the camera-slit set on opposite sides of H_1 should give differences in the form and appearance of the flocculi. It is hoped that these tests can soon be made with the tower telescope and 30-foot spectroheliograph.

COMPUTING DIVISION.

The work of the computing division, under the direction of Mr. Adams, has progressed very satisfactorily during the year. Miss Ware has devoted all of her time to the measurement of the heliographic positions of flocculi with the heliomicrometer, for the purpose of determining the solar rotation period. The results obtained indicate that the heliomicrometer is admirably adapted for this work, though the proper motions of many flocculi are so great as to suggest that a less precise mode of measurement might serve nearly as well for a study of the mean velocity of the solar rotation. However, it has not yet seemed advisable to modify the system employed, since the discussion of the proper motions themselves, which could not be so well determined with a less accurate measuring instrument, may yield results of value. In case it should become desirable to modify the apparatus so as to permit greater rapidity of operation, it will only be necessary to rule one hemisphere of the globe of the heliomicrometer with meridians and parallels 1° apart. The approximate positions of the flocculi can then be estimated (as in the globe-measuring machine used at the Yerkes Observatory) with some gain in rapidity, but with corresponding loss in precision. The selection of flocculi for measurement, as at present carried out, requires considerable time, since the greatest care is exercised in the choice of objects which do not undergo material change of form during the interval between the plates. Less care in this regard would probably result in little loss of precision in the determination of the mean rotation period, but, as in the case of less accurate measures, the resulting positions would not be sufficiently precise to yield accurate values of the proper motions. The results of the first year's work, which are now under discussion, should leave no doubt as to the most effective means of continuing this investigation.

As stated in my last report, it is desirable to obtain measurements of the areas covered by the calcium flocculi, to serve as an index to the solar activity. In the first method devised for this purpose the photograph was divided into a series of squares 10° on a side, the total area included extending 40° in latitude and 40° in longitude on each side of the sun's center. The intersections of the squares were marked by a dot of ink on the glass side of the plate with the aid of the heliomicrometer. A quantity representing the areas and the intensities of the principal flocculi in each square was measured photometrically. The density of the background was also measured, in order to eliminate large errors which would otherwise result. It was found, however, that the quantity remaining after the background had been eliminated was too small to permit its variations, from day to day or from square to square, to be followed with the necessary precision. For this reason a simpler method of procedure was adopted. A piece of plain glass is placed in front of the negative and the principal flocculi in each square are painted out with black paint. Very faint or small flocculi are not included. The

PLATE

STEEL BUILDING FOR 60-INCH REFLECTOR.

area covered by the black paint, in each 10° square, is then measured with the photometer.

While it might appear that the selection of flocculi must be very arbitrary, and subject to large errors, it has not yet been found possible to devise a more satisfactory method. Miss Smith, who has carried on this work from the beginning, has acquired considerable skill in the selection of objects to be measured, and the same plate, when independently measured on different dates, gives results as accordant as could be expected under the circumstances.

During a recent visit to England I discussed this subject with Professor Turner, who had devoted much attention, when chief assistant at Greenwich, to the similar problem of measuring the areas of the faculæ, and with Mr. Maunder, who now has charge of the measurement of the direct solar photographs of the Greenwich series. They agreed that the selection of faculæ on the Greenwich plates is necessarily an arbitrary matter, so that precise determinations of their areas can not be obtained. They also considered that the areas of the flocculi, as measured here, are as precise as the nature of these objects warrants. If possible, the method of measurement will be improved, but it appears extremely doubtful whether better results can readily be obtained.

Miss Lasby has devoted most of her time to the measurement of photographs taken by Mr. Adams for the spectrographic determination of the solar rotation. The results of this investigation, which are given elsewhere in this report, indicate that a very high degree of precision has been obtained in the measures. Plates will be taken in the future, from time to time, in the hope of detecting any possible variation in the rotation period. Miss Lasby has also devoted some time to the measurement of photographs of spectra corresponding to the center of the sun and to points near the limb.

Miss Burwell, who has only recently joined the computing division, has been engaged for the most part in determining the scale errors of the Hartmann spectro-comparator recently received from Zeiss, and of the smaller Gaertner measuring machines.

In addition to the time devoted to the general supervision of the work, Mr. Adams has made a large number of measures of spectra. He has also taken many photographs on Mount Wilson and has given much attention to the reduction and discussion of observations.

CONSTRUCTION DIVISION.

The work of the construction division, which has been continued under the superintendence of Mr. Ritchey, has been much heavier than in any previous year. The various operations in progress have included the work of the optical and instrument shops, the completion of the Mount Wilson road, the transportation of materials to the summit of the mountain, the construction of the Hooker building in Pasadena, and the erection of buildings on Mount Wilson.

60-inch Reflector.—In April, 1907, when the 60-inch mirror was receiving its finishing touches, it was found one morning that the entire surface was covered with scratches. How these were produced is a mystery which has not been solved. The extreme precautions taken to avoid scratches, some of which were mentioned in my last report, have been rigorously observed during the year. Indeed, it is difficult to see how greater care could have been exercised by the opticians. It can only be supposed that some very small but hard particles, not removed in the processes of washing and straining always employed, were present in the rouge. However caused, the scratches were so serious as to require regrinding of the mirror, which had to be brought back to the spherical form. In other words, the entire work, except the rough grinding and the polishing of the rear surface, had to be done over again. The advantages of experience are illustrated by the fact that the work was entirely completed in August, with an accuracy so great that no residual error exceeds one-tenth of a wave. The Institution is certainly to be congratulated on the rapidity and success of this work, the great difficulties of which can be appreciated only by those who are familiar with the technical details involved. The final tests of the mirror were made with parallel light, secured by the aid of a plane mirror 36 inches in diameter, made by Mr. Ritchey for this purpose. A very fine 36-inch spherical mirror was also made for the purpose of testing the plane mirror. The other work of the optical shop includes the figuring of various plane and convex mirrors for the 60-inch reflector and the two plane mirrors required for the tower telescope. As some of these are 12 inches thick, and some elliptical in form, special apparatus had to be constructed for grinding them.

The mounting for the 60-inch reflector has advanced satisfactorily. The parts, as received from the Union Iron Works Company, were set up in our erecting house and much work has been done on them. The most delicate operation was the cutting of the large worm-gear, 10 feet in diameter, for which special machinery had to be constructed. It may safely be said that the precision of this work will leave nothing to be desired. The driving-clock has been completed, as well as many other parts of the mounting, which are now being finally assembled. The skeleton steel tube has arrived, but the end sections of the tube, which are to carry the various convex and plane mirrors required for the Newtonian and Cassegrainian arrangements of the mounting, have not yet reached us.

The completion of the steel building and dome for the 60-inch reflector was greatly delayed by long-continued strikes at the Union Iron Works, but most of the parts have now reached Pasadena and are being hauled to the mountain. The construction force on Mount Wilson, under the superintendence of Mr. George D. Jones, has completed the large concrete pier for the mounting, the pier and concrete house for the fixed spectrograph, and the concrete foundations for the steel building. They are now engaged in

erecting and riveting this building, as shown in plate 8. In view of unforeseen delays, occasioned in part by labor troubles and strikes, and in part by the difficulties of transportation over the mountain road, the dome can not be entirely completed before the rainy season, as had been hoped. This will prevent the erection of the 60-inch reflector on Mount Wilson before the spring of 1908.

Tower Telescope.—In Contributions from the Solar Observatory No. 14 a plan is described for a vertical cœlostat telescope which I devised last summer as a result of the experience gained from the use of the Snow telescope. This instrument, which has recently been completed, is shown in plate 9. It consists of a steel tower 65 feet in height, which carries a cœlostat and second mirror, from which the sunlight is reflected vertically downward through a 12-inch objective of 60 feet focal length, mounted near the summit of the tower. The solar image is thus formed a short distance above the ground level, where it enters the slit of a Littrow grating spectrograph of 30 feet focal length, which stands in a cylindrical concrete well 8.5 feet in diameter, constructed in the earth immediately under the tower. The instrument includes several novel features, among which may be mentioned extremely thick mirrors, to reduce distortion by sunlight; arrangements for reflecting sunlight on the silvered backs of the mirrors, to compensate residual bending; great elevation of the cœlostat, to reduce the effect of disturbances caused by heated air rising from the ground; the use of a vertical light beam instead of a horizontal one; the provision of a subterranean laboratory, nearly constant in temperature, for the spectrograph, etc.

On account of the pressure of work in our instrument shop, the cœlostat and second-mirror support were obtained from Brashear and the Littrow spectrograph from Gaertner. All other work on the instrument was done by our own men, however, including the driving mechanism for the spectroheliograph, rails for the cœlostat, etc. As remarked above, the cœlostat and second mirrors were also made in our optical shop.

The preliminary tests of the tower telescope show that it accomplishes the purposes for which it was designed, *i. e.,* the mirrors change their figure so slowly that long exposures can be given with the 30-foot spectroheliograph, and the definition is at all times better than with the Snow telescope. Excellent photographs of the solar spectrum (at center and limb) have been obtained in the third and fourth orders of the 30-foot spectrograph.

Other Construction.—As usual, much miscellaneous work was done in the instrument shop during the year. This included the building of an addition to the erecting-house, to contain the electric truck; the reconstruction of the motors and other parts of the truck; the erection of an addition to the carpenter shop, fitted with a wood planer, for the construction of the 100-inch grinding machine; considerable work in connection with the Hooker building; minor apparatus, repairs of instruments, etc.

Miscellaneous work on the mountain included the installation of an underground electric-power line to replace the pole line damaged by the great storm of January, 1907; the rebuilding of several miles of telephone line also injured by the storm; the construction of a concrete storehouse near the Monastery; repairs of buildings, etc.

Mount Wilson Road and Transportation.—Work on the Mount Wilson road was well advanced in December, but near the end of that month and early in January a succession of heavy snowstorms made it necessary to discontinue operations until the close of the rainy season. So far as can be judged from the information available, these storms were almost without precedent here. The snow on the summit of the mountain was over 5 feet deep on a level. The destructive effect of the storms was enhanced by the fact that the snow was preceded by rain, which froze on the telephone and power wires and poles in great masses. Below the snow-line, which extended more than half way down the mountain, the precipitation of rain was enormous, and the road naturally suffered severely, both from washouts and from landslides. In April, when work on the road was resumed under the superintendence of Mr. Jones, the repairs of the damage done by the storms necessarily occupied much time. However, these operations were pushed with such vigor and success that the road was ready for use on May 21, 1907. On account of the precipitous nature of the mountain slopes and the many difficulties experienced from landslides, the construction of the road has proved to be a heavy undertaking.

The electric truck, for transporting 5-ton loads over the Mount Wilson road, was delivered to us in November, 1906. As the date of delivery was much later than had been agreed upon, there remained no opportunity to test the truck before the rainy season. After a single trip, in which the truck, without load, ascended the road to a point not far below Henniger's Flats, further trials had to be made in Pasadena, where no certain conclusions could be drawn as to the truck's performance. Five-ton loads were successfully hauled, for short distances, over grades as high as 17 per cent, but no endurance test could be made. Early in the spring, as soon as the condition of the road permitted, the mountain tests were resumed. It then appeared that the power was insufficient to meet the existing conditions. For this reason it became necessary to reconstruct the motors. The long time required for shipment to Grand Rapids prevented the work from being done in the East, and it was accordingly carried out in our own shop. The four motors are mounted in the four wheels of the truck, and the small clearance permitted but few changes to be made. Nevertheless, the reconstruction was so successful that the power of each motor was nearly doubled. A Brennan engine of 45 H. P., together with a 17 K. W. generator, were then substituted for the 25 H. P. Continental engine and 12 K. W. generator previously employed. As thus reconstructed the truck carried 3-ton loads to the summit

VERTICAL CŒLOSTAT OR TOWER TELESCOPE.

of the mountain, but with considerable difficulty, owing to its great weight, the heavy grades, and the softness of the roadbed at many points after weeks of exposure to the sun. As the expense of operating the truck is necessarily large, it has proved to be cheaper to haul the materials for the steel dome and building (aggregating about 150 tons) to the summit by mule teams. The limiting load that can now be taken up in this way is about 2 tons, but a four-mule team driven by a good teamster accomplishes relatively more than the truck run by three skilled men. The use of the truck will therefore be confined to the transportation of the 5-ton pieces of the 60-inch mounting, and other large parts.

100-inch Reflector.—The 4.5-ton glass disk for the 100-inch reflector was ordered from the French Plate Glass Companies, of St. Gobain, France, in September, 1906. In view of Mr. Hooker's desire that the work be pushed forward as rapidly as possible, the Hooker building, in which the grinding, figuring, and testing of the mirror is to be done, was constructed during the winter. A large room 34 feet square and 20 feet high, opening into a long testing-hall, has been provided for the work. The walls of this room are very heavy, made of brick laid in cement, and covered with a roof of reinforced concrete. This portion of the building, which is separated from the other part by iron doors, may therefore be regarded as fire and earthquake proof—a consideration of no small importance, in view of the nature of the work to be done within it. A heavy steel I-beam, supported over the doorway, carries a traveling crane, by means of which the mirror-disk and heavy parts of the grinding-machine, one of which weighs 3.5 tons, can be brought into the room and handled when necessary during the progress of the work. The testing-hall, 100 feet long and 10 feet wide, will permit the mirror to be tested from the center of curvature or with parallel light. For the latter purpose a 60-inch plane mirror will be constructed on the grinding-machine previously used for the mirror of the 60-inch reflector. On one side of the testing-hall are rooms for the grinding and polishing tools and for the apparatus required to maintain the polishing-room at a uniform temperature. There is also a large fireproof vault, for the storage of astronomical photographs. On the other side of the hall a series of computing offices is provided, affording, with the rooms already available in the adjoining building, suitable accommodations for a large staff of computers. It is hardly necessary to say that the Hooker building forms a most valuable addition to our resources in Pasadena.

Work on the grinding-machine for the 100-inch mirror is well advanced and will probably be completed before the glass reaches us from France.

I visited the Paris offices of the French Plate Glass Companies in June and discussed with the director, M. Delloye, various questions involved in the manufacture of the 100-inch disk. At that time the special appliances needed for the work at St. Gobain had been completed, and the first attempt

to cast the disk was to be made early in July. It was decided to extend the time of annealing over a very long period, so as to reduce the danger of internal strain arising from too rapid cooling. In view of the special difficulties of the case, it is probable that repeated trials will be necessary before a satisfactory disk can be obtained.

Mr. Ritchey has commenced work on a preliminary design for the mounting of the 100-inch reflector in order that general estimates covering the cost of this work can be prepared. Details of the design, however, can not be completely worked out until the mounting of the 60-inch mirror has been tested in practice. It is hoped that suitable tests of this nature can be made in the erecting-house at Pasadena during the coming winter, by direct stellar photography.

RESEARCHES OF THE SMITHSONIAN EXPEDITION ON MT. WILSON.

By C. G. Abbot.

By invitation of the Director of the Solar Observatory of the Carnegie Institution of Washington, a small expedition from the Smithsonian Astrophysical Observatory was located on Mount Wilson from May to October, inclusive, in 1905 and 1906, for the purpose of making measurements of the energy of the solar radiation. The principal investigations made were:

(1) The determination of the value of the "solar constant of radiation," or in other words, the intensity of the solar radiation in calories per square centimeter per minute, outside the atmosphere and at the earth's mean distance from the sun.

(2) The relative intensity of rays of the different wave-lengths in the solar spectrum outside the atmosphere, and the probable temperature of the sun as connected therewith.

(3) The transmission of the earth's atmosphere for rays of different wave-lengths.

(4) The quantity and quality of the light scattered by the sky.

(5) The reflecting power of clouds for all angles of incidence and reflection, and from this the determination of the amount of solar radiation which would be lost to the earth if the atmosphere were completely cloudy.

A full account of the expeditions and results is included in volume II of the Annals of the Astrophysical Observatory of the Smithsonian Institution, now in press. A brief summary is as follows:

In 1905 two small observing shelters were erected and equipped with piers and apparatus, the first of these containing the spectrobolographic apparatus required for observing the transmission of the atmosphere for nearly monochromatic rays, the second containing a new form of standard pyrheliometer adapted to register automatically and continuously the total intensity of the sun's radiation at the earth's surface. Observations were begun with secondary pyrheliometers in May, 1905, and complete series of observations for determining the "solar constant of radiation" were made about twice or thrice each week from June 5 to October 29, 1905. In 1906, "solar constant" work was begun May 10, and continued until October 22. In all, 130 determinations of the "solar constant" were secured, all included between the limits 1.93 and 2.14 calories per square centimeter per minute, and giving a

mean value of about 2.03 calories. The accuracy of the work depends upon the uniformity of the transparency of the sky for the hours when the sun's altitude is rapidly changing, and all the internal evidence of the observations indicates that on most days the conditions above Mount Wilson were excellent in this respect. It is believed that the separate determinations of the "solar constant" are usually accurate, relatively to one another, within 1 per cent; so that the considerable range of values from 1.93 to 2.14 calories indicates a real variability of the solar radiation outside the earth's atmosphere. This conclusion has been tested in every way yet thought of, and seems unshaken.

The variations do not depend on changes of the transparency of the earth's atmosphere or of the amount of its humidity, for there is no connection, either direct or inverse, which holds consistently as between variations of the "solar constant" values and variations of the transparency or humidity of the atmosphere, as observed on different days.

There is a real change of solar radiation at the limit of the atmosphere which depends on the change of distance between the earth and the sun. This change, which amounted to between 3 and 4 per cent during the interval covered by the measurements, was accurately shown by the results, so that confidence in the reality of the other changes observed is increased by this circumstance. Measurements were made in Washington nearly simultaneously with some of those on Mount Wilson. The Washington values of the "solar constant" of radiation are evidently less trustworthy than the Mount Wilson values, but differ from them by only about 3 per cent on the average. Accordingly, great confidence is felt in the accuracy of the method of determination, which leads to substantially identical results when applied at two stations separated by 3,000 miles in longitude and 1 mile in elevation.

The transmission of the atmosphere for monochromatic rays of 44 different wave-lengths was determined on Mount Wilson on 130 different days. Comparing average values with average values for Washington, the average transmission of the mile of air nearest sea-level has been obtained. It proves that about as much light is scattered from the direct beam in the mile of air nearest sea-level as in the many miles of atmosphere above Mount Wilson.

The exact form of the solar-spectrum energy curve outside the atmosphere has been delineated, and also the forms resulting at the surface of the earth for different altitudes of the sun.

In 1906 a third small observing shelter, surmounted by a tower 50 feet in height, was erected on a point overlooking deep canyons on three sides, and suitable apparatus was installed there to measure, at given altitudes and azimuths, the reflecting power of the level ocean of cloud which rose sometimes to within a hundred feet of the base of the tower. From these measurements it has been computed that the earth, if it were wholly clouded over, would reflect to space 65 per cent of the sun's radiation.

Measurements were made from this tower of the intensity of radiation scattered from the sky at different altitudes and azimuths, and of the comparative quality of sunlight and skylight.

With the data secured at Mount Wilson and at Washington a new determination of the albedo of the earth has been made, and it is found that 37 per cent of the solar radiation is reflected to space.

The expeditions to Mount Wilson have been in personal charge of Mr. C. G. Abbot, and Mr. L. R. Ingersoll, of the University of Wisconsin, assisted in the work for 3 months of each season.

DEPARTMENT OF TERRESTRIAL MAGNETISM,*

L. A. Bauer, Director.

The plan of work outlined for a bureau to be engaged in the investigation of "such problems of world-wide interest as relate to the magnetic and electric conditions of the earth and its atmosphere, not specifically the subject of inquiry of any one country but of international concern and benefit," published in Year Book No. 2, pages 203 to 212, embraced the following as the chief problems of investigation:

(*a*) A magnetic survey of ocean areas and unexplored regions.
(*b*) International observations of the variations.
(*c*) Observations in ocean depths and atmospheric regions.

This plan having received the approval of the Board of Trustees, the Department of Research in Terrestrial Magnetism was established and work was begun on April 1, 1904. The Department at the end of the present fiscal year will therefore have been in operation for about three and one-half years, this annual report being now the fourth one submitted.

In reporting upon the operations of the past year, as well as in the summarization of what has been accomplished thus far during the existence of the Department, it will be advantageous to follow the order given above for the main problems of research.

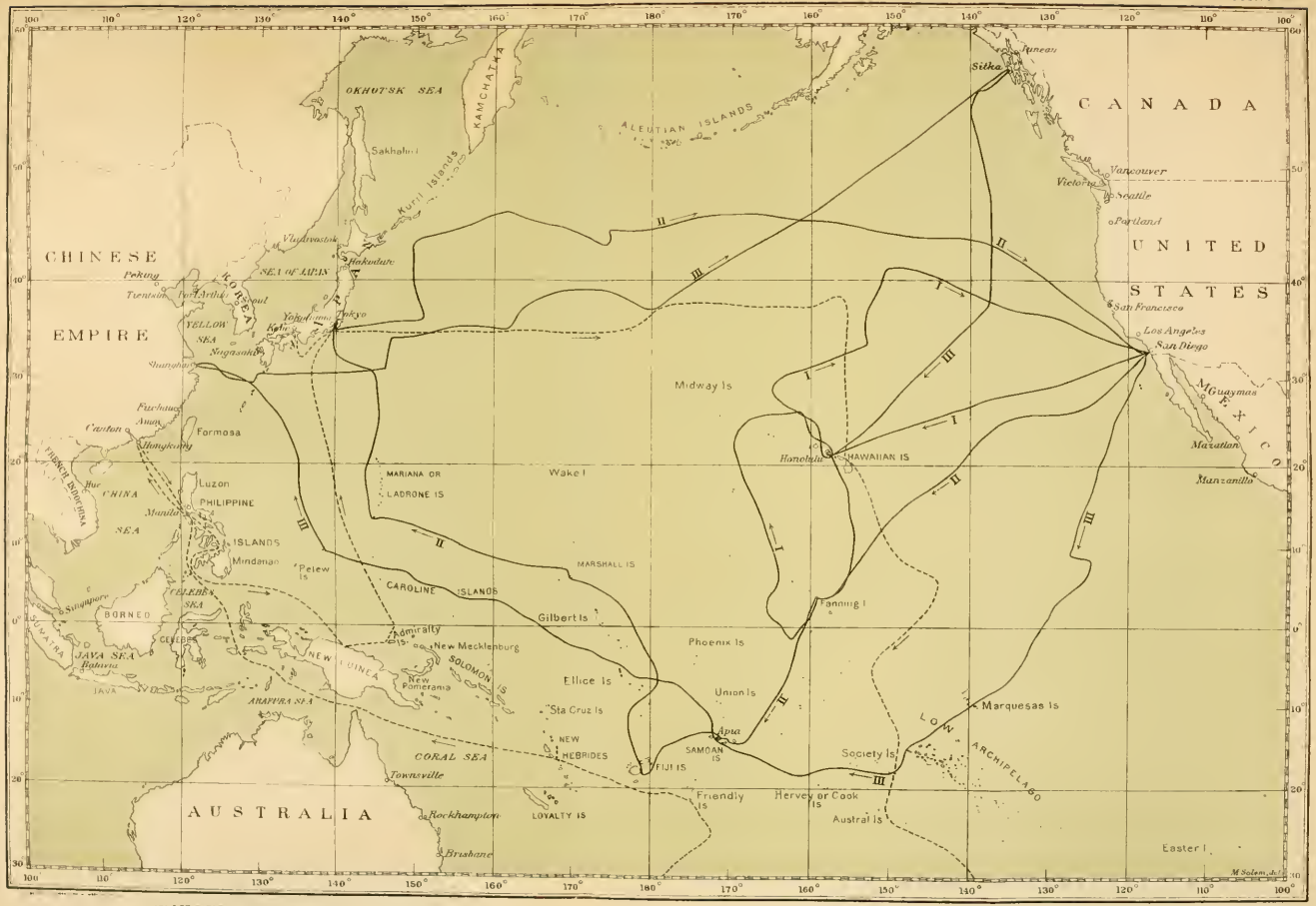
MAGNETIC SURVEY OF OCEAN AREAS.

The magnetic survey yacht *Galilee* was continued in operation throughout the year in the Pacific Ocean, under the command of Mr. W. J. Peters, who has now successfully and energetically conducted the work of this vessel for the past two years. He has made favorable report upon the individual work of the various members of his party.

At the close of the last fiscal year the *Galilee* had returned to her home port, San Diego, California. During the interval, November 1 to December 22, 1906, various shore observations, harbor swings, and investigations were made and the vessel overhauled and outfitted preparatory to her third cruise. Mr. Peters reported at the office in Washington, November 16 to 22, for consultation and discussion of future work. On December 22 the *Galilee* set sail from San Diego and entered upon "Cruise III," the scientific party consisting of Commander W. J. Peters, Magnetic Observers J. C. Pearson and D. C. Sowers, and Dr. G. Peterson, surgeon and recorder; Captain J. T. Hayes, as heretofore, was the sailing-master.

The port of Nuka Hiva, Marquesas Islands, was reached on January 18, 1907, where no harbor swing of the vessel being possible, the *Galilee,* upon

* Grant No. 401. $57,000 for investigations and maintenance. (For previous reports see Year Book No. 3, pp. 68–74; Year Book No. 4, pp. 264–274; and Year Book No. 5, pp. 236–242. Address: The Ontario, Washington, D. C.



CRUISES OF THE MAGNETIC SURVEY YACHT "GALILEE" FROM AUGUST 1, 1905, TO SEPTEMBER 1, 1907

(TOTAL LENGTH ABOUT 50,000 NAUTICAL MILES)

DOTTED LINES SHOW TRACK OF "CHALLENGER" EXPEDITION, 1872-1876

completion of the shore work, proceeded on January 24 to Tahiti, arriving there January 31. During a stay of nineteen days at this port, harbor swings and land observations were carried out in detail. The next stop was made at Apia, Samoan Islands, where, between March 3 and 14, various standardizations and comparisons of instruments were made at the Apia Magnetic Observatory. This is now the second time that these highly essential observations and checks on the ship instrumental constants were obtained at this important observatory, established under the auspices of the Göttingen Academy of Science. The present observer-in-charge, Dr. G. Angenheister, as well as the retiring observer-in-charge, Dr. F. Linke, rendered the *Galilee* all requisite assistance. However, harbor swings with the *Galilee* could not be attempted at this port.

Leaving Apia March 14, Yap Island was made on April 14. Here various observations and swings consumed nine days. Sailing from Yap Island April 23, Shanghai was reached on May 8, and the principal stop was made. Comparisons of the *Galilee* instruments were made with the standard instruments of the Zi-ka-wei Observatory, the Director, Father J. de Moidrey, S. J., furnishing every facility possible. Swings of the vessel, on account of the high tides and absence of all auxiliary motive power on the *Galilee* could not be made here in port, but had to be undertaken directly after leaving Shanghai on May 31, and they were even then secured with great difficulty and consumed two days.

From Shanghai Mr. Peters was directed to proceed with the vessel due east towards Midway Island, putting in port there, if conditions did not make the same hazardous with an all-sailing vessel, and from thence to make Sitka, in order to cover this passage during as favorable a part of the year as possible. However, tempestuous weather was encountered on almost the entire trip, blowing the vessel out of her set course, preventing swings or rendering impossible magnetic declination observations because of absence of sun or stars, so that the course and program of work outlined could be followed only approximately. For about 750 nautical miles from Shanghai the course was practically about the same as that of the *Challenger*, and no landing on Midway Island could be safely attempted. After following a generally easterly course to longitude 181.5° east, latitude 37° north, course was laid directly for Sitka, the *Galilee* entering this harbor July 14, 1907. In spite of the bad weather the trip of 5,400 nautical miles was made in 45 days, averaging about 120 nautical miles per day.

The Director met the *Galilee* at Sitka on July 28, inspected the work and instrumental outfits, and discussed with the commander the future work. Some instrumental changes were made, consisting chiefly of newly received Lloyd Creek dip circle 189 and a new Richie liquid compass fitted with a deflecting arrangement, devised by the Department, for determining directly the horizontal component of the earth's magnetic intensity. Furthermore, a spare gimbal stand was mounted for the purpose of attempting certain atmos-

pheric electricity observations. Mr. J. C. Pearson having been continuously on sea duty as magnetic observer from January 1, 1906, to July 31, 1907, was relieved and assigned to land and shore duty, as elsewhere related, Mr. P. H. Dike being assigned to his place on board the *Galilee*. Mr. Dike, in addition to taking part in the magnetic work, will undertake the experimental work in atmospheric electricity, for which he has specially qualified himself by work abroad, as stated in last year's report, and by further investigations at Washington. No other change in the personnel took place.

The cruise from Sitka was to be as follows: Sitka to Honolulu; thence Jaluit, Marshall Islands; from there to Christchurch, New Zealand; then return to San Francisco via Easter Island and Callao, Peru. It is expected that the *Galilee* will complete this cruise about May, 1908. While she has been well suited for the necessary preliminary experimental work, future operations can be conducted more profitably and economically in a vessel specially designed for ocean magnetic surveys, which, because of freedom from magnetic properties, would materially reduce the labor of observing as well as the labor of office reductions.

The requisite instrumental determinations and comparisons having been completed at the Sitka Magnetic Observatory, the *Galilee* put to sea once more on August 10, and arrived at Honolulu on August 28, having had a favorable passage. Here the vessel required overhauling and outfitting before continuing the cruise above outlined. After securing the necessary instrumental determinations and comparisons at the Honolulu Magnetic Observatory, the *Galilee* left Honolulu September 26, and at the end of the fiscal year had reached Jaluit, Marshall Islands, where connection was made with the *Galilee* observations at this port in 1906.

The *Galilee* party is under obligations, for valuable assistance rendered in the instrumental comparisons, to Dr. H. M. W. Edmonds, observer-in-charge of the Sitka Magnetic Observatory, and to Mr. W. F. Wallis, observer-in-charge of the Honolulu Magnetic Observatory, the facilities of both of these observatories having been courteously extended by special authorization of the Superintendent of the U. S. Coast and Geodetic Survey, Mr. O. H. Tittmann.

The computations have been kept as closely up to date as was possible. The observing party has reached a high state of efficiency and transmits the records of observations with commendable promptness. For example, on September 17, all the records up to the arrival of the *Galilee* at Honolulu on August 28 were on file at the office in Washington. Furthermore, observations when received in general have been computed and revised by the observing party. Were it not for the troublesome deviation corrections, which can not be determined finally until the close of a cruise, the results could be made ready for publication with little additional office labor immediately upon receipt of the observations.

Besides the magnetic work proper, the question of sufficiently accurate geographic positions for the points of observations has received further special attention by the consulting hydrographer, Mr. G. W. Littlehales, and the commander, Mr. Peters. Various astronomical methods of observation and of computation were subjected to careful investigation.

The oceanic magnetic work accomplished thus far may be briefly summarized as follows:

The aggregate length of the present Cruise III, up to arrival at Honolulu August 28 last, is about 22,400 nautical miles, and as the two previous cruises (1905 and 1906) had a combined length of about 26,000 miles, the *Galilee,* during the period of August 1, 1905, to September 1, 1907, has cruised in all nearly 50,000 miles over regions in the Pacific Ocean where before there were but very few carefully executed magnetic observations.

A complete determination of three magnetic elements (magnetic declination, magnetic inclination, and intensity of magnetic force) has been secured, on the average about every 200 or 250 miles along the entire route. Plate 10, showing the various cruises, will give a better idea than words can convey as to what has actually been accomplished, as also how far the state of our knowledge of the distribution of the magnetic forces over the Pacific Ocean will have been advanced when the *Galilee* has cruised over the regions from Honolulu to New Zealand and from thence through the South Pacific and has returned to San Francisco next year.

In addition to magnetic results on the ocean, the *Galilee* has obtained a number of highly important results on the islands and ports where stoppages were made, some of the points being reoccupations of former stations, and has besides made a series of valuable intercomparisons of instruments at the various observatories visited.

All the results obtained by the Department at sea and on land up to March of the present year were furnished the U. S. Hydrographic Office in time to enable it to issue last May a new "Chart of the lines of equal magnetic variation for 1910" (lines of equal magnetic declination), representing not a little improvement in the lines over the Pacific Ocean. Along some of the well-traversed routes in this ocean, errors in the existing charts amounting from 1° to 5° were disclosed. These are corrections of considerable importance to navigators, to say nothing of the advancement of our knowledge along purely scientific lines.

The values of the magnetic dip as given over the North Pacific Ocean by the existing charts have been found to be, in general, too small by about 1° to 3°, and the values of horizontal intensity too high by about one twenty-fifth part.

With the aid of the data furnished, the U. S. Hydrographic Office has in preparation also "Chart of the lines of equal magnetic dip" and a "Chart of the lines of equal magnetic intensity." It would hardly be advantageous

for the Institution to prepare such charts itself at the present time, but instead it will be better to wait until the general completion of the work. However, all institutions and persons interested are being furnished with the manuscript results.

MAGNETIC SURVEY OF LAND AREAS.

In pursuance of the policy of the Department not to undertake in general magnetic work in the regions where there are institutions charged with such work, or where persons with the aid of special grants from scientific societies have already in hand the desired investigations, the work during the past year has been conducted in localities where data were greatly needed and would not soon be acquired.

Besides the work enumerated below, arrangements are in progress for the undertaking of systematic work in Africa under the joint auspices of the governments concerned and of the Department, beginning, it is hoped, in 1909 or earlier. The Department is fortunate in being able to avail itself of the cooperation of Prof. J. C. Beattie, of the South African College, at Capetown, during his furlough in 1909.

Alaska.—The Director, in connection with his inspection of the *Galilee* at Sitka, made magnetic observations at Sitka, Juneau, and vicinity. Assisted by Magnetic Observer J. C. Pearson, he furthermore made a special investigation of the anomalous magnetic conditions existing in the neighborhood of the local magnetic pole at Treadwell Point, found by him at this place in 1900. Here a source of local attraction exists affecting the mariners' compasses, a mile distant in Gasteneau Channel, about ¾ point (about 8°), a quantity large enough to put a ship on the rocks were it not allowed for in the navigation of the vessel. Because of its extreme localization and intense concentration, whereby changes of point of observation by but few inches in a horizontal or in a vertical direction cause considerable changes in the magnetic elements, this anomaly afforded opportunity for investigations of extreme interest along various lines of inquiry. While stronger magnetic anomalies have been found elsewhere, the published results have not revealed anywhere as steep gradients of the magnetic elements, *i. e.*, changes in these elements with variation of horizontal or vertical distance from the points of attraction as found here. Thus, for example, within a distance of 2 to 3 feet, at a height of about 5 feet above the surface, the compass would change its direction by nearly 180°. This region, furthermore, gave opportunity to make some interesting tests as to how closely in such a region of disturbance the earth's magnetic forces are "coupled," *i. e.*, whether in addition to a couple there is a resultant magnetic force producing a motion of translation of the magnetic needle either in a horizontal or in a vertical plane. The special report on this work shows that some interesting results along this line of inquiry have been obtained.

Bermuda Islands.—Between July 2 and August 9 Mr. H. W. Fisk, magnetician, was assigned to the investigation of the well-known anomalous conditions prevailing in the earth's magnetic field in this region. This work was in continuation of certain previous investigations made chiefly by officers of the British Admiralty and of the exploring vessel *Challenger,* and more recently, as far as the magnetic declination was concerned, by Mr. J. F. Cole, who worked under the auspices of the Bermuda Biological Survey (Prof. E. L. Mark, Director). Mr. Fisk's work was likewise done in cooperation with Professor Mark, who facilitated and furthered the work in every possible way. The Department is also under obligations for the courtesies extended by the various local authorities. In addition to complete observations at 5 primary stations, approximate determinations of the three elements were made at 35 secondary stations and dip and intensity results at 32 additional secondary stations. The reduction and discussion of this valuable work is in progress; the results will be embodied in a special report.

Canada.—En route to Sitka the Director made magnetic observations at Winnipeg (reoccupying the station of last year), at Banff, and at two mountain stations in the vicinity, viz, Sulphur Mountain (7,350 feet above sea-level), and Tunnel Mountain (5,540 feet), the station in the village of Banff being at an altitude of 4,520 feet. The observations at these three stations in the National Park of Canada were made with a special view of ascertaining the suitability of this region for investigations respecting the variation of the magnetic elements with altitude. The results showed that but little, if any, local disturbance existed, so that it will be worth while at some future time to carry on the investigations on a more elaborate scale and to occupy still higher peaks, of which there are a number in the vicinity comparatively accessible.

Upon his return from Sitka, the Director also reoccupied the Coast and Geodetic magnetic station of 1903, located at Victoria, British Columbia. At Winnipeg a consultation was had with the commissioner of the Hudson Bay Company, Mr. C. C. Chipman, regarding transportation facilities for observers of the Department in the regions of Canada not easily accessible. Arrangements will accordingly be made, with Mr. Chipman's cooperation, for work in 1908 in the regions named. Thus it will be possible to secure a series of magnetic stations along the Mackenzie River, reoccupying at the same time certain stations at which observations have been made by Franklin, Simpson, Lefroy, King, Klotz, Ogilvie, and others.

Mr. J. C. Pearson, magnetic observer, after having been relieved of sea duty upon arrival of the *Galilee* at Sitka, assisted the Director in the special investigations at Treadwell Point, and left Juneau on August 16 for the Yukon Territory, in order to secure magnetic observations at about 8 stations between White Pass, Dawson, and the International Boundary, most of the points being reoccupations as closely as possible of Ogilvie's stations of

1887-88. On his return to Vancouver he observed at two stations between Vancouver and Banff, and thus completed a series of stations, chiefly by the Department observers during the past year, extending across the entire continent in Canada. He has, furthermore, reoccupied Warren's Landing and Norway House, on Lake Winnipeg, in accordance with the arrangements made with the commissioner of the Hudson Bay Company. At these two stations observations have been made heretofore by Lefroy and Klotz. He also made magnetic observations at West Selkirk, Manitoba.

The work in Canada, as during the previous year, is being done in cooperation with the Dominion Meteorological Service at Toronto (R. F. Stupart, Director) and the Dominion Observatory at Ottawa (W. F. King, Director). Both of these Dominion institutions are now making field observations, the plan of cooperation between them and the Department providing against any unnecessary duplication and enabling results to be obtained effectively and expeditiously.

Central America.—From February 21 to June 28 Mr. J. A. Fleming, magnetician, determined the three magnetic elements at 3 stations in British Honduras, 2 stations in Honduras, 12 stations in Guatemala, 5 stations in Panama, 8 stations in Costa Rica, and 1 station in the Canal Zone; 31 stations in all. In view of the great difficulties of travel in these countries, especially so during the period of war between Nicaragua and Honduras, Mr. Fleming had made most commendable progress by the time it was necessary to close the field work on account of the advance of the rainy season. At four of his stations observations by previous observers are available, and hence valuable secular variation data will result. Upon his return to Washington he took charge of the office during the Director's absence. Mr. Fleming's results indicate that the magnetic conditions are considerably disturbed over the areas covered. Not a little interest was shown in his work by various local officials, surveyors, and scientific men, and he was treated everywhere with every possible courtesy and given effective assistance.

China.—Dr. C. K. Edmunds, magnetic observer and professor of physics and electrical engineering at the Canton Christian College, has continued in charge of the operations in this country, conducting them during his vacations. The Department is fortunate in having so energetic an observer available in this region. From November, 1906, to January, 1907, he carried out various comparisons at Hongkong and Honglok, and made the computations for the different observations reported upon last year. During February, 1907, he made complete magnetic observations at Honglok, Yeungkong, Kochow, and Fachow. Up to July, as far as his college duties permitted, he completed computations and made the necessary arrangements for continuous field work from August to December, his college having generously granted him the required furlough for this period. Having been furnished

with a new outfit of instruments from the office, he made careful intercomparisons between this outfit and those used in the previous work, courteously loaned him by the observatories at Zi-ka-wei and Hongkong.

Mention should again be made of the effective and generous assistance rendered Dr. Edmunds by the directors of these observatories. Upon Father J. de Moidrey, S. J., Director of the Zi-ka-wei Observatory, had fallen the chief burden of the cooperative work, especially also because of the necessary instrumental determinations and comparisons required during the visit of the *Galilee,* as elsewhere mentioned. The Department is not a little indebted to him for his kind thoughtfulness and solicitous care. It is expected that by October Dr. Edmunds will have completed the magnetic observations at about 26 stations in the provinces of Kiangsi, Kiangsu, Shantung, Chihli, Shengking, Honan, and Hupeh. By the end of 1907, provided no unexpected delay is encountered, a fairly detailed magnetic survey of the southeastern part of the Chinese Empire, between approximately the meridians 113° and 122° east and parallels 22° and 42° north, will have been completed by him. He is training a Chinese student in furtherance of the plan to have magnetic work done by natives of the countries as far as possible.

Mexico.—Mr. J. P. Ault, magnetic observer, having been relieved from sea duty at the conclusion of Cruise II of the *Galilee,* was assigned to field duty in Mexico in cooperation with the National Observatory at Tacubaya (Señor Felipe Valle, Director). During the period December 1, 1906, to February 17, 1907, he determined the three magnetic elements at 15 stations, and had secured comparisons with the instruments used by the Mexican parties. Mr. D. C. Sowers, magnetic observer, while en route to join the *Galilee* at San Diego, observed at 2 stations in Mexico, Hermosillo, and Guaymas (repeat station). The observers of the Department thus confined themselves chiefly to the region north of the twenty-fifth paralled. Their results were promptly reduced and furnished to Director Valle, who, in cooperation with the Department, put two parties in the field—the eastern party in charge of Engineer Señor Abel Dias Covarrubias and the western party in charge of Señor Manuel Morena y Anda, embracing the Pacific Coast from Manzanillo to Guaymas, inclusive of Lower California. Upon the organization of these parties, and after having secured the necessary intercomparisons of instruments, the Department observer was withdrawn, so as to leave the further development of the magnetic survey of Mexico to the Mexican authorities. Señor Valle's interest in this work will no doubt assure its early completion.

South Pacific Islands.—Mr. G. Heimbrod, temporarily associated with the Department as magnetic observer, completed, during November and December, 1906, the work intrusted to him in the South Pacific Islands, by obser-

vations at Auckland, New Zealand, securing comparisons of instruments at the observatories at Melbourne and Sydney, Australia, and by making the final determination of constants at the Apia Magnetic Observatory with the instrumental outfit courteously loaned by the latter observatory. For this additional courtesy and assistance rendered by the Apia Observatory the Department is further indebted. Having returned in good condition to the observatory the instruments loaned, he resumed his private surveying practice at Suva, Fiji.

Miscellaneous.—The Department cooperated with the expedition to the Aleutian Islands under the direction of Prof. T. A. Jaggar, in charge of the Department of Technology of the Massachusetts Institute of Technology. Prof. H. V. Gummere, of the Drexel Institute of Philadelphia, a member of this expedition, was given the required training in magnetic observations and the constants were determined for the instruments to be used by him and plan of work furnished him.

Mr. R. B. Oliver, member of a special exploring expedition in the Kongo Free State, was given the necessary training at the office to enable him to obtain values of the magnetic declination with the compass attached to his surveyor's transit. He was furthermore acquainted with the work done by various previous expeditions under the auspices of the Belgian Government, and informed where secular variation data are desired.

The land magnetic survey work executed thus far may be briefly summarized as follows:

The three magnetic elements have been determined at 301 primary stations, distributed over the following countries: Africa (1), North America (197), South America (1), Asia (67), Bermuda (5), Australasia (4), Pacific Islands (25). At about 70 of these stations observations exist for previous periods, hence the reoccupation of these by the Department has furnished valuable secular variation data. Special investigations have also been made in locally distributed regions in which observations were secured at a number of additional secondary stations, *e. g.,* at Treadwell Point (about 25) and in the Bermuda Islands (about 67); consequently, in addition to the observations at the above 301 primary points, approximate determinations were made at about 100 secondary stations.

Intercomparisons of instruments have been secured at the following magnetic observatories: Apia (Samoan Islands), Baldwin (Kansas), Cheltenham (Maryland), Christchurch (New Zealand), Cuajimalpa (Mexico), Havana (Cuba), Hongkong (China), Honolulu (Hawaiian Islands), Melbourne (Australia), Shanghai-Zi-ka-wei (China), Sitka (Alaska), Sydney (Australia), Tokyo (Japan), Toronto-Agincourt (Canada), Vieques (Porto Rico).

INTERNATIONAL OBSERVATIONS OF THE VARIATIONS.

Under this heading is embraced all observations that pertain to the variations and fluctuations of the magnetic elements, such as are included in the work of a magnetic observatory, in the reoccupation of previous stations for secular variation data and special investigations, as, for example, in connection with the total solar eclipse. It has not been possible as yet to undertake any observatory work, but some such work will have to be undertaken within the near future to provide adequately for the needs of the Department.

The establishment of repeat stations or reoccupation of previous ones is systematically under way, as reported upon under "Magnetic survey of land areas." This work will in the coming year receive further extensive development, as it is proposed to establish a series of such stations around the globe to permit of regular reoccupation within intervals of not over five years. In connection with this work, which must necessarily keep pace with the magnetic-survey work, all previous data are being collected and suitably arranged, and will shortly be ready for publication.

The magnetic and electric observations, made in connection with the total solar eclipse of 1905, have now been received from nearly every country that responded to the appeal of the Department for international simultaneous work during this eclipse. It is hoped that before long the results can be submitted for publication. It can only be noted here that the independent researches of various investigators, such as van Bemmelen, Nippoldt, and Nordmann, confirm the result reached from the observations made in the United States during the total solar eclipse of 1900, under the writer's direction, viz, that there is an observable magnetic fluctuation in connection with a total solar eclipse. Professor Oddone, a member of Professor Palazzo's Tripoli expedition, conducted in cooperation with the Department, believes he has proved that an appreciable atmospheric electric fluctuation also occurs during a total solar eclipse.

OBSERVATIONS IN OCEAN DEPTHS AND ATMOSPHERIC REGIONS.

The work under this head has necessarily not advanced beyond the preliminary stages. Methods and instruments for determining the variations of the magnetic elements with altitude or depth have received some consideration, however. Special attention is being paid at present in the course of the survey work to find localities suited for such work. Thus in December, 1905, an examination was made of the region around the Grand Canyon of the Colorado; this summer, as elsewhere related, the region about Banff, in the National Park of the Dominion of Canada, was examined by the Director, as also the Yellowstone National Park. The first two localities named appear well suited; the latter, however, would present difficulties because of

the prevalence of local disturbances. In the establishment of a magnetic observatory, however, it might be worth while to consider as a site the vicinity of Mammoth Hot Springs, in the Yellowstone National Park, primarily because of the insured freedom from electric car disturbances.

Observations under this head embrace, first, the changes in the absolute values of the magnetic elements, with change of level, and, secondly, the changes in the variations (periodic and otherwise) with change of level.

In the fall of 1903, when the Director was in charge of the magnetic work of the Coast and Geodetic Survey, he investigated the suitability of some of the copper mines in the vicinity of Houghton, Michigan, and found that it would be possible to install instruments at various levels down to 5,000 feet, in chambers from which the ore had been removed, and which were at that time sufficiently distant from extraneous disturbing influences, such as might result from electric installations. Preliminary arrangements were made in cooperation with President McNair, of the Houghton College of Mines, but, being unable to secure promptly from foreign makers the desired instruments, the contemplated work could not be carried out.

The problem of the changes in the magnetic variations with depth is at present being independently investigated also in Germany, under the supervision of Prof. Adolf Schmidt, in charge of the Potsdam Magnetic Observatory, a preliminary account of which has been published in the December, 1906, issue of the journal Terrestrial Magnetism.

SPECIAL OBSERVATIONAL WORK.

Besides the various observations required at Washington in connection with the testing and standardizing of instrumental outfits, it has been necessary to make special investigations in order to disclose the cause for outstanding differences between the results as derived from various instruments and various methods, *e. g.,* in connection with the oceanic magnetic work. One of the questions which arose in this connection was as to how exactly the balancing or coupling of the earth's magnetic forces takes place, *i. e.,* whether there is any resultant magnetic force because of which an appreciable pressure would be exerted on the pivot of a compass needle or on the agates of a dip circle. It was found that for some reason, which could not be explained by the present theory of the instruments involved, constants of the ship instruments, as determined by comparative observations on the generally disturbed islands in the Pacific Ocean with the usual land instruments, did not fit precisely the observations made on the ship over the deep seas.

If in addition to a couple arising from the earth's magnetic forces there also exists a resultant force, then if the magnet were carefully weighed in various positions, *e. g.,* vertically north end up and then north end down, or horizontally north end north and next north end south, differences in the

weight of the magnet will be disclosed for the various positions, the magnitude of the differences depending upon the closeness with which the earth's magnetic forces are coupled at the place of observation.

With a view of testing this matter and establishing the degree within which the coupling takes place in various magnetic fields, the Director, in connection with his trip of inspection to the *Galilee* at Sitka, made a series of weighings of an octagonal magnet, using a Becker non-magnetic analytical balance. These weighings were made at the following points: Sitka (auxiliary building of the Sitka Magnetic Observatory), Treadwell Point (region of great local disturbance), Juneau (Occidental Hotel), Victoria (in the open air, as also inside a hotel), Baldwin, Kansas (Magnetic Observatory), Washington, District of Columbia, and Cheltenham, Maryland (Magnetic Observatory).

In a region of pronounced local disturbance, such as exists at Treadwell Point, there is no question as to appreciable differences in the weighings of the magnet in the four positions above enumerated. At the other places mentioned, where the local field is approximately uniform, there exist some indications that exact coupling may not invariably take place. At Treadwell Point the average difference for four points of observation was about 1/500000 part of the weight of the magnet (33.627 ± grams), the weight for north end south being greater; for the two vertical positions the average difference was nearly 1/100000 part, the weight for north end down being the greater.

Further observations will be required before more definite announcement can be made regarding this interesting question, the main purpose at the present time having been to get some idea as to the magnitude of the quantities to be measured. The investigation has been amplified so as to include more orientations of magnet and be conducted with various magnets and in various magnetic fields.

ATMOSPHERIC ELECTRICITY WORK.

As stated in connection with the work of the *Galilee,* Mr. P. H. Dike, after having made various experiments and investigations at Washington to determine upon the feasibility of certain atmospheric electricity observations at sea, was assigned to the *Galilee* at Sitka on August 1 to secure the practical experience required under the actual conditions involved. A synopsis of what he proposes to attempt is contained in the June, 1907, issue of the journal Terrestrial Magnetism. A preliminary report has been received from him embodying the result of the experiments which he was enabled to carry out on the recent cruise of the *Galilee* from Sitka to Honolulu, August 10 to 28. He states: "Up to the present most satisfactory work has been done with the Gerdien conductivity apparatus; observations have been made on 5 days, giving results fully as high as are expected on land, being of the

same order of magnitude as those obtained by Mr. J. E. Burbank, under the auspices of the Department, in Labrador." In connection with the potential gradient work some preliminary experiments were made. Investigations will be continued on the remainder of the cruise.

OFFICE WORK.

The major part of the time of the office force at present available is consumed in the duties involved in the administration and supervision of the field work in progress and in the reduction of the current observations. It is the constant endeavor to keep the office reductions apace with the field work, for only in this way can defects in instruments and methods be detected with desirable promptness and be immediately remedied. Thus the observer in the field is ever in close touch with the office.

The multitudinous reductions and computations for Cruises I and II of the *Galilee* were completed, besides a number of related theoretical investigations undertaken. As already stated, abstracts of the results of the observations are promptly supplied to the institutions and persons interested.

Assistance has been rendered the U. S. Coast and Geodetic Survey in the preparation of the publication containing a compilation and discussion of the results of the magnetic observations in the United States for the period 1905.

The major portion of the office investigations enumerated in the report of last year, it is confidently hoped, will be completed and ready for publication by the end of the calendar year.

The report on the scientific work of the Ziegler Polar Expedition, a quarto volume of 630 pages and 46 inserts, has been completed by Mr. Fleming outside of office hours, and is now being distributed by the National Geographic Society to parties interested. The executors of the estate of William Ziegler have turned over to the Department all the scientific observations and computations of the expedition for safe-keeping and future reference.

Numerous abstracts of recent publications have been prepared by various members of the Department, particularly so in the field of atmospheric electricity by Mr. P. H. Dike.

Addresses have been made by the Director before the Society of Arts, Boston, Massachusetts, and also the Society of Engineers of Washington, District of Columbia, describing in detail the operations of the Department.

Publications of the Department have been regularly forwarded to interested parties in all parts of the world.

OBSERVING AT LOCAL MAGNETIC POLE, TREADWELL POINT, ALASKA.

ANTHROPOLOGY.

Dorsey, George A., Field Museum of Natural History, Chicago, Illinois. Grant No. 420. *Investigation among the tribes of the Caddoan stock.* (For previous reports see Year Book No. 2, p. xv; Year Book No. 3, p. 83; Year Book No. 4, p. 53, and Year Book No. 5, pp. 55, 56.) $2,000.

The work of this year has been almost entirely of a linguistic nature. Recognizing the necessity of being able to interpret Pawnee in order to translate properly the large number of songs and rituals which have accumulated during the past five years, the work of preparing for publication certain material already obtained was suspended, and Dr. Dorsey, accompanied by Mr. Murie, spent ten weeks during the winter in New York, where, under the direction of Dr. Franz Boas, the fundamental principles of the Pawnee language were studied and methods of recording texts, etc., were learned. On return to Chicago work has been carried on exclusively in the preparation of a volume of texts, the manuscript of which it is hoped will be ready for the printer by the end of the present year. The source of these texts consists of narratives of personal experiences, traditions, myths, etc., collected on phonographic records last autumn from a well-known Skidi by the name of Roaming Scout. These have all been transcribed and are now being verified from the records. A sketch of the grammar will be prepared for publication with the texts. As a result of the acquisition of this material certain portions of the manuscript prepared last year on the Society and Religion of the Skidi will be revised, and much new information acquired from the records will be incorporated in this manuscript.

The manuscript on the mythology of the Pawnee has been printed during this year as Publication No. 59 of the Carnegie Institution of Washington. Certain minor papers resulting from investigation have also been printed. A supplement to the above-mentioned volume will be prepared during the winter. It will embody many songs, the music of which has already been transcribed and carefully treated by Dr. E. von Hornbostel, who spent three months in Chicago last year making certain psychological investigations among the Pawnee, beside making a careful study of their music. This supplement will also contain a résumé of Dr. Dorsey's investigations in the mythology of the tribes of the Caddoan stock and a comparison of incidents with those of other mythologies of North America.

To prepare for publication the music and translation of the songs and rituals which have already been recorded, and which will form part of the memoir on the Society and Religion of the Skidi, will demand greater time than was originally anticipated. It is believed, however, that another year will complete this work.

ARCHEOLOGY.

American School of Classical Studies at Athens. James R. Wheeler, Chairman of Managing Committee, Columbia University, New York, N. Y. Grant No. 407. (*a*) *Excavations at Corinth,* $1,500. (*b*) *Maintenance of a fellowship in architecture at Athens,* $1,000. (For previous reports see Year Book No. 4, p. 54, and Year Book No. 5, p. 56.) $2,500.

(*a*) *Excavations at Corinth.*—Mr. B. H. Hill, Director of the school, reports that he has been much hampered this year by the depletion of the labor market in Greece and by the greatly increased expense of work, owing to the rise in value of the drachma; but the regular campaign of excavation has been conducted, with some important topographical results.

The necessary work of clearing the market-place was continued, though no important finds were looked for here. A round Roman building, dedicated by one Babbius Philenus, was discovered, with a sufficient number of architectural fragments to render restored drawings possible. The Roman shops ("South Shops") were cleared out, and a Greek stylobate at the back of them uncovered. In this quarter, on the slope of the Temple Hill, a neolithic stratum was found containing obsidian tools, and above this a small and very archaic female figure.

Trial trenches were sunk in the region between the Fountain of Glaucé and the theater, which resulted in the discovery of the Odeum mentioned by Pausanias as among the buildings on the road to Sicyon. This discovery is of very considerable importance in Corinthian topography. It makes it certain that the road to Sicyon left the market-place on the northwestern side; it shows the general direction of the road, and consequently indicates the quarter of the city in which certain of the older sanctuaries, mentioned by Pausanias, notably that of Athena Chalinitis, may be looked for. It also proved beyond a doubt that the great temple, the well-known landmark of Old Corinth for so many years, was really that of Apollo, since it is mentioned by Pausanias as being on the right as he starts out on the road to Sicyon. The excavators have believed this to be the case, but it is now proved. A fuller report of excavations will be printed in the Journal of Archeology and in a Bulletin on Corinth, which the School has nearly ready for publication.

(*b*) *Fellowship in Architecture.*—Mr. Henry D. Wood, of Philadelphia, has held this fellowship during the past year, and his work has been so satisfactory that he has been reappointed for another year. Mr. Wood's chief work has concerned the Propylæa of the Acropolis. He has studied carefully the scattered fragments of the building, and has succeeded in correcting various points in earlier theories of restoration. In other cases he has placed correct theories on a scientific basis of fact. In part of the roof structure his studies are of special interest and importance.

It is expected that the American Journal of Archeology will shortly publish a more detailed account of this work.

American School of Classical Studies in Rome. Andrew F. West, Chairman of Managing Committee, Princeton University, Princeton, New Jersey. Grant No. 408. (*a*) *Maintenance of two research fellowships in classical archeology,* $1,600. (*b*) *Publication of results of scientific investigation,* $1,000. (For previous reports see Year Book No. 4, p. 54, and Year Book No. 5, pp. 56, 57.) $2,600.

(*a*) The school was enabled to secure Dr. Esther B. Van Deman and Mr. Morris Austin Harmon as research fellows for the year 1906–07. Their reports follow:

Dr. Van Deman writes:

During the first few months of the year, the work on "The Imperial Atrium Vestae" was revised and enlarged. To this was added also a section on "The Remains of the Republican Atrium Vestae and the Domus Publica."

The later months of the year were spent in the study of Roman brickwork, the aim of which was, (1) the determination of the various periods into which such work is to be divided, with a general description of the main features which distinguish each period, and (2) the classification chronologically of the more important brick structures in and near Rome.

A short paper was completed, which is soon to be published, entitled "Notes on a Few Vestal Inscriptions." A longer discussion on "Epigraphical Evidence Concerning the Cult of Vesta Publica," is partly completed.

The material has been, during the year, completed for a discussion of "The Vestal Statues," among which are many examples of the use of earlier Greek models for later Roman portrait statues. Several unpublished vestal heads and fragmentary statues will soon be published.

Mr. Harmon reports:

"My principal undertaking—the one in consideration of which I was awarded the fellowship—was the study of the Cæretan red ware. This ware, of which most of the extant examples came from the early excavations at Cervetri, occurs in two shapes—pithoi about 3 feet tall and large plates from 1 to 2.5 feet in diameter. It is made of coarse reddish-yellow clay, full of black spiculæ; the outside of the pithoi and the upper surface of the plates sometimes show a coating of cinnabar. The pithoi are sometimes plain, but usually have a series of long vertical flutings on the belly; above this, and occasionally below, appears a narrow frieze of stamped figures in low relief. These friezes are made either by repeated applications of a square stamp, which gives a paneled zone, or by the use of a cylindrical stamp, which, rolled around the vase as one rolls a tracing-wheel, gives a continuous zone of recurring subjects. The plates always show a zone of continuous relief impressed on the rim and usually another on the inner wall. Only one plate, which differs in several other respects from the rest of the series, bears a square stamp. In addition to the reliefs, many of the plates have a set of concentric circles in the center. This by way of brief reminder of the general features of the class.

For the study of these vases I now have the material well in hand. I have collected and read all the literature bearing directly on the subject, and know either from description or personal examination 244 vases, exclusive of those which bear no decoration. Interest centers, of course, in the

stamped friezes. They show the use of 83 different stamps, of which 29 are square and 54 cylindrical.

Before I undertook this task there were accessible in printed description only about 60 vases, bearing 47 different stamps. Many of the descriptions were defective or faulty, and of the 39 illustrations, most of which are published in Pottier's catalogue, there are few that are good, owing mainly to the excessive reduction in scale. As I shall be able to give full and accurate descriptions of all the stamps and to publish at least 30 new ones in an adequate way, the accessible material will be about doubled by my publication. I have aimed to make it as complete as possible, and feel that little can have escaped me. There may be a few scattered examples that I do not know, but it is not likely that any of them would present new features.

The allied Greek fabrics with reliefs obtained by means of a cylinder stamp are as yet very little known. Outside of the Sicilian ware few examples have been found, and classification has hardly been attempted. I shall be able to add something here by publishing an interesting piece from Tanagra in the Athens Museum, one from Macedonia in the Berlin Museum, and one from the Caucasus in the Louvre, and shall try to do something in the way of classification.

So much of my time has been spent in gathering this material that I have had little chance to work it up. Consequently it is too early to speak with confidence of results. I hope to establish the location and date of the factory and its relation to other factories making similar ware, to fix its place in the history of Etrusco-Ionic art, and, if possible, to determine the influences which shaped that art. The treatise will be long and will stand in need of rich illustration. It can hardly be completed before next May, perhaps not as soon as that. Could I have devoted all my time to it during the past year I might have been able to finish it, but other matters have claimed a large share of my attention.

Next in importance to the Cæretan ware was the Catalogue of the School Museum. It is now completed and in the hands of Professor De Cou for revision. It includes everything except a quantity of Egyptian objects recently loaned by Professor Norton, and reaches more than 500 numbers, some of which are of considerable interest. The specimens are all numbered and as well arranged as the very limited space of the room would permit. They are to be transferred this summer to more commodious quarters in the old dining-room, where they can be displayed to great advantage. I hope that this will lead to an increase of interest in the museum. It would not be either difficult or expensive to foster it, and the School would benefit greatly thereby. Not only would the museum be an attraction to visiting archeologists, but it would be made a valuable help in teaching, especially in seminary work.

I have also nearly ready my paper on a certain group of black-figured cylices. It might have been completed this spring, but I held it back in the hope of discovering other vases of the same type in Paris or London. The search was fruitless, however, and the paper will be sent in as soon as I have had an opportunity of going over it again with the resources of a good library at my command.

Of late I have been interested in the Panathenaic amphoræ, and have taken notes that may result in a paper when I find time to work them up. There are two matters which I should like to straighten out—the dating of those amphoræ which bear no inscription, and the meaning of the date on the inscribed amphoræ.

Apart from my archeological studies I have also been engaged in a certain amount of philological work the past year. A little paper entitled "Ignis arumphea" was printed in the Rheinisches Museum this winter (1907, p. 159), and just before leaving Europe I sent to Prof. C. U. Clark, of Yale, now in Marburg, the first draft of an essay on the clausulæ employed by Ammianus Marcellinus, which I hope to see published soon.

My interests have thus been rather varied. I should have preferred to let the philological work wait until my return to America, but I feared that my discoveries might be anticipated. The year has been extremely profitable to me, and I hope that its results will prove satisfactory to the Committee, to which, in closing this report, I desire to express my thanks for the opportunity which I have enjoyed.

(*b*) Besides the work of these two research fellows a second volume of School Papers, embodying various results of archeological research, is being prepared by an editorial committee composed of Prof. J. C. Egbert, of Columbia University; Professor Planter, of Western Reserve University, and Professor Bennett, of Cornell University. The volume will probably appear during the coming winter.

Brigham, William T., Bernice Pauahi Bishop Museum, Honolulu, Hawaii. Grant No. 341. *Surveying, photographing, and describing the heiau, or ancient stone temples of the Hawaiians, in connection with a treatise on "Ancient Hawaiian Worship."* For previous report see Year Book No. 5, p. 58.) $2,500.

During the past year the field work has been on the largest island of the group, Hawaii, and while there were formerly only five or six of the old temples that were more than names, more than ten times as many have been located and their original plan has been restored to some extent. This proves to have been varied and the variations are often puzzling. Where modern alterations have converted the ancient inclosures into cattle-pens or other economic uses foreign to their original intent, it is generally possible to eliminate these; but sometimes such alterations consist in removing portions of the walls or platforms, and then it is more difficult, if not impossible, to conjecture the intent of the builder.

It is hoped that the final report on these investigations will be ready before the end of another year. For this a large number of photographs of idols and paraphernalia of worship are ready, besides views of the heiau.

Müller, W. Max, Philadelphia, Pennsylvania. Grant No. 355. *Continuation of archeological researches in Egypt.* (For previous reports see Year Book No. 3, p. 84, and Year Book No. 5, p. 59.) $2,000.

During September and October, 1906, Dr. Müller worked among the temple ruins and tombs at Thebes, first on the east side of the Nile and later on the west side, collecting chiefly inscriptions and representations which bear on the intercourse of the ancient Egyptians with Asia. A large number of copies, drawings, photographs, tracings, and paper squeezes were collected, almost entirely in and near Thebes.

ASTRONOMY.

Campbell, W. W., Lick Observatory, Mount Hamilton, California. Grants Nos. 421 and 231. (*a*) *Pay of assistants to take part in researches at the Lick Observatory,* $4,000. (*b*) *Measurement and reduction of photographic plates of Eros,* $3,000. (For previous reports see Year Book No. 2, p. xix; Year Book No. 3, p. 86; Year Book No. 4, pp. 82–83, and Year Book No. 5, pp. 86–88.) $7,000.

(*a*) In the spectrographic determination of stellar velocities there have been employed, as assistants in the past year:

Mr. Keivin Burns, October 1, 1906, to October 1, 1907.
Dr. B. L. Newkirk, October 1, 1906, to August 1, 1907.
Miss Leah Allen, September 9, 1907, to October 1, 1907.

Mr. Burns secured 52 spectrograms with the Mills spectrograph attached to the 36-inch refractor, and made first measures and reductions of 40 spectrograms and definitive measures and reductions of 223 spectrograms. This completed the measurement and reduction of all the spectrograms obtained with the Mills spectrograph, as originally mounted, between August, 1897, and July, 1903. Mr. Burns devoted three months to a study of the residuals afforded by the separate spectrum lines on 750 plates selected from those obtained in this 6-year period. The stars were classified in the order of their spectral types, on the Harvard system (XII to XVIII), but independently of the Harvard assignment of types for the individual stars. The residuals were tabulated in the order of the types, and the determination of the corrections to individual lines in the various types, in order to reduce all to a homogeneous system, is approaching completion. In the same connection Mr. Burns is making a study of blended lines, *i. e.,* of lines apparently single with the moderate dispersion of the Mills spectrograph, which the much higher dispersion of Rowland's solar spectrograms recorded as composed of several separated lines. We can not safely adopt the mean of Rowland's wave-length of the individual lines as the wave-length of the resulting blend. The proper values must be determined with each spectrograph employed.

Dr. Newkirk measured definitively 338 spectrograms, reduced 81 definitively, and reduced 98 approximately. In addition he made a study of the errors of the lines of titanium and iron in the comparison spectra, upon which all the velocity determinations depend. Miss Allen is reducing definitively the unreduced measures by Dr. Newkirk.

Throughout the year Mr. Sanford has read the microscopes of one of the two declination circles of the meridian instrument, in Professor Tucker's program for determining fundamental star positions. Mr. Sanford has been engaged steadily with the reduction of these observations, and has relieved Professor Tucker of many routine details; for example, by taking charge of the standard clocks upon which the right ascensions of the program depend.

(*b*) The Crossley reflector photographs of Eros have been under continued measurement and reduction during 10 months of the year, by Professor Perrine, with the assistance of Misses Chase and Hobe. The second half of taking differences of measured distances, forming means and checking for the plates measured, has been completed, and all the measures have been reduced to standard rectangular coordinates. All the star positions, with the exception of those on one date, have been reduced to mean places for 1900.0, using the star-places supplied by Mr. Hinks, Chief Assistant, University Observatory, Cambridge, England. The reductions to apparent place, the parallax corrections, and the parallax factors have been computed, and the positions of Eros interpolated from the ephemeris. The meridian observations of Eros have been completely reduced and compared with the ephemeris for the purpose of determining the systematic corrections to the ephemeris.

At present a new reduction of the parallax plates to mean place is in progress, using a different grouping of the comparison stars. This will serve the double purpose of testing two different methods of reduction and of supplying an independent check on the accuracy of the calculations.

Newcomb, Simon, Washington, District of Columbia. Grant No. 409. *Investigations in mathematical astronomy, statistical methods, and economic science.* (For previous reports see Year Book No. 2, p. xxi; Year Book No. 3, p. 90; Year Book No. 4, pp. 83–84, and Year Book No. 5, p. 88.) $5,000.

Discussion of the Mean Motion and other Elements of the Moon from Eclipses and Occultations from the Period of the Earliest Babylonian Records to the Present Time.—This work has been almost suspended for a year, but is now again taken up with the intention of bringing it to completion as soon as possible. Although the immediate object of the work is the history of the moon's motion, this is by no means the sole important object. It is anticipated that it will result in a more accurate determination of some of the fundamental elements of astronomy, especially the motion of the sun and of the ecliptic and the absolute right ascensions of the fundamental stars.

Investigation of the Action of the Planets on the Moon.—This work was published in June last. A great mass of test computations were necessary while it was going through the press, and this occupied most of the time during the first four months of the year.

Investigation of Terrestrial Temperatures, to Determine whether they are Affected by Variations in the Sun's Radiation of Energy.—This work was brought to completion and made ready for the press in June last, but still awaits publication by the American Philosophical Society. It embraces a discussion and comparison of fluctuations of temperature in various widely

separated regions of the globe during the past 60 years, investigated by rigorous methods of statistical correlation. One conclusion is that there is a fluctuation in the general temperature of the globe having the same period as that of the sun's spots, and a coefficient of about 0.14°C. The entire range during the 11-year period is therefore about 0.28° C, or about 0.5° F. Apart from this, there are no perceptible fluctuations, and any imperceptible fluctuations which may exist can not exceed a fraction of 1 per cent of the whole, so that their influence on terrestrial temperatures and other meteorological elements is too small to produce any important effect. It should be added that the conclusions relate only to the thermal radiation, and not to magnetic or electric emanations.

New Theory and Tables of Mars.—It has been found that Professor Newcomb's tables of Mars, published ten years ago by the Nautical Almanac Office, fall below the degree of precision required in astronomy, and must be reconstructed. The most difficult part of the work will be the recomputation of the general perturbations of the second order, which can be done only by an experienced mathematician, well trained in this kind of work. What has so far been done comprises the computation of an ephemeris of the planet since 1753, when accurate observations commenced. This ephemeris is still unfinished and is laid aside to complete the work on occultations.

Astrophysics.—The great interest attaching to the so-called canals of Mars led the writer to make an experimental study of certain branches of the psychology of vision, relating especially to the appearance presented by faint and difficult markings on the surface of a planet. The results of this study, with their application to the case of Mars, were published in the Astrophysical Journal for July, 1907.

Methods of Probable Inference, Especially in Statistics.—During a visit to California last summer Professor Newcomb took occasion to put the preliminary chapters of a work on this subject into shape, and to develop some formulæ of demography. This is the work with which he expects to be mainly occupied when that on occultations is out of the way.

Russell, Henry N., Princeton, N. J. Grant No. 207. *Photographic determination of stellar parallaxes.* (For previous reports see Year Book No. 3, pp. 92, 93, and Year Book No. 5, p. 89.) $1,000.

The work of the past year has consisted in the measurement and reduction of photographs taken at Cambridge, England, by Dr. Russell and Mr. A. R. Hinks. During the year 97 plates have been measured, making a total of 219 plates, of 38 fields, which have been measured and completely reduced; 28 additional plates, which were very kindly obtained by Mr. Hinks after Dr. Russell left Cambridge, have just been received and will be measured.

Seventeen series of plates have been completely discussed and least-square solutions made for the parallax of 23 stars shown thereon. The results for 11 of these stars have been published in the Monthly Notices of the Royal Astronomical Society for June, 1905, and December, 1906. Besides these, the approximate parallaxes of the 140 comparison stars employed have been determined, the results showing that these are in general less than the errors of determination (which are themselves satisfactorily small).

The completion of the 14 series now in progress will raise the number of "parallax stars" to 44 and of comparison stars to about 240. To this total may be added 8 stars observed at two epochs with the color-screen, for which approximate determinations can be made.

Dr. Russell hopes that the results for all the above may be presented to the Institution before the close of the coming academic year, thus completing his work.

Schlesinger, Frank, Allegheny, Pennsylvania. Grant No. 422. *Completion of parallax computations begun under direction of Dr. G. E. Hale.* $300.

The calculations for the parallaxes of all of the 24 stars under consideration have been completed. It remains to make the computations for the general discussion of these results and to prepare them for publication. This work will probably proceed somewhat slowly on account of the small amount of time that Dr. Schlesinger is enabled to spare for this work from other and more pressing duties.

BIBLIOGRAPHY.

Eames, Wilberforce, Lenox Library, New York, New York. Grant No. 343. *Completion of Sabin's "Dictionary of Books Relating to America," from "Smith to Z."* (For previous report see Year Book No. 5, p. 90.) $3,600.

The work of completing the manuscript copy for the remaining part of the alphabet (S to Z) of Sabin's Dictionary of Books Relating to America has progressed steadily since January 1, 1907, having been carried on, under Mr. Eames's supervision, by Mr. Frederick C. Bursch. The printing will probably be deferred until the completion of the manuscript, probably next June.

Fletcher, Robert, Army Medical Museum, Washington, District of Columbia. Grant No. 410. *Preparation and publication of the Index Medicus.* (For previous reports see Year Book No. 2, p. 23; Year Book No. 3, p. 95; Year Book No. 4, p. 85, and Year Book No. 5, p. 91.) $12,500.

The volume of the Index Medicus for 1906 illustrates still further than at last report the remarkable growth of periodical medical literature throughout the world. The first volume of the first series of the Index Medicus,

published in 1879, comprised 684 pages. The volume for 1906 contains 1,596 pages. Transactions of societies are included under the above general term of "periodicals." In addition to this steady increase there has been added of late years a new and highly important series of reports from laboratories devoted to research in biological sciences. The volume of the Index Medicus for 1907 is being duly issued.

Weeks, F. B. (under direction of Dr. G. F. Becker), U. S. Geological Survey, Washington, District of Columbia. *Bibliography of geophysics.* Grant No. 423. (For previous reports see Year Book No. 3, p. 81; Year Book No. 4, p. 86, and Year Book No. 5, pp. 90–91.) $1,200.

Mr. Weeks reports that work upon this bibliography is practically completed and that author cards and index cards will be submitted to the Institution in a short time.

BOTANY.

Burbank, Luther, Santa Rosa, California. Grant No. 404. *Experiments in plant development.* (For previous reports see Year Book No. 4, p. 125, and Year Book No. 5, p. 136.) $10,000.

Within the limits of this annual report Mr. Burbank finds it possible to give only a brief account of his experiments and operations in plant improvement. This work, which has engaged his attention for the past 39 years, is of steadily growing interest, and its cumulative results are more evident than ever before. He has now under experimental test over 3,600 distinct species of plants, and many thousand varieties of some of these. Over a million seedling plants are raised each year for selection and for the study of variation from the effects of crossing. The newly developed fruit and fodder plants are attracting great interest—not only in the United States, but in many foreign countries. New species have been established which go on their way with the same unchanging precision of typical characters as do any of the species established in the past by nature.

One of the interesting recent results is the production of a distinct new species of solanum (*S. burbanki*) by crossing *S. guinense* var., a native of central West Africa, with *S. villosum,* of Chili. The experiments leading to this new species were begun in 1895. From the cross-bred seeds numerous plants were grown in the early part of the season of 1896, all practically alike. Another generation of numerous individuals was brought into fruit the latter part of 1896, this third generation embracing some 2,000 individuals, all as much alike as if raised from any wild, fixed species. In 1907 the fourth and fifth generations have been produced, and among 30,000 plants, which have flowered and ripened abundantly, no variation toward

either parent, or in any other direction, has occurred, and this new hybrid may therefore be classed as a distinct new species. *Solanum guinense* is a strong, bushy perennial, bearing large quantities of black fruits of most unpleasant qualities; *S. villosum* is a dwarf, procumbent annual, which produces abundant clusters of small, hard, green berries, but the fruit of the new species is delicious, resembling the low-bush blueberry of the Eastern States—*Vaccinium pennsylvanicum* in color, flavor, consistency, and general appearance. The species is grown with ease and will probably prove to be of great commercial value.

Extensive experiments of extreme interest and importance have been conducted with *Zea mays,* the common corn. This annual grass is evidently a native of America, but has not within historic times been found wild, the grass-like plant teosinte of Central America being its nearest wild relative. Like all other grasses, the kernels of the progenitors of *Zea mays* many years ago no doubt grew at the top of the stalk, like sugar-cane, wheat, barley, etc. By these experiments the plant has been carried back, through many forms, to the original simple grass. It has also been crossed with teosinte. Numerous photographs, showing the strange ancestral forms, have been obtained, and it is hoped that the experiments, which are of especial importance to biologists, may be extended through another year.

The new giant opuntias so far produced will endure only about the same degree of freezing as the fig or eucalyptus trees. An effort is being made to produce hardy varieties which, it is hoped, can be cultivated successfully in more northern climates.

Dr. George H. Shull has taken notes of Mr. Burbank's experiments and has made much progress, but new results of past experiments are accruing very rapidly, and additional trained scientific observers could be usefully employed upon this work.

Dr. W. A. Cannon, of the Desert Botanical Laboratory, has under microscopical examination several of Mr. Burbank's hybrids, and other hybrids are being studied by Professor Webber, of Cornell University.

CHEMISTRY.

Acree, Solomon F., Johns Hopkins University, Baltimore, Maryland. Grant No. 372. *Accurate physical investigations on the urazoles.* (For previous reports see Year Book No. 4, pp. 134, 135, and Year Book No. 5, p. 140.) $300.

Professor Acree submits the following abstracts of several investigations carried out with the aid of the above grant:

On the Salts of Tautomeric Compounds. (By S. F. Acree: American Chemical Journal, vol. 37, p. 71.)—It is well known that when the silver salts of some tautomeric compounds, such as amides, are treated with alkyl halides, at ordinary temperatures, oxygen esters are formed in large amounts, whereas the potassium and sodium salts yield, at higher temperatures, largely nitrogen esters. If acetoacetic ester is heated with a mixture of silver oxide and an alkyl halide, both oxygen and carbon derivatives are formed, but the sodium salt, under the same conditions, gives practically only a carbon derivative. In general, however, when a salt of a tautomeric amide is treated with an alkyl halide, both oxygen esters and nitrogen esters are formed.

To account for such reactions of amides, several theories have been proposed:

(I) The potassium and silver salts have different but definite structures. The potassium salt is a nitrogen compound and the silver salt is an oxygen derivative (Comstock's older theory).

(II) When one salt yields with a certain reagent two products, one is formed directly and the second by rearrangement of the first (Wheeler's theory). Wheeler assumed that all salts of the amides are oxygen derivatives, and that these first yield oxygen esters which then form addition products with the alkyl halide and rearrange into nitrogen derivatives.

(III) When one salt yields with a certain reagent two products, one is formed by direct substitution of the metal and the other by the formation of an unstable intermediate addition product between the salt and the other reagent (theories of Nef and of Michael).

(IV) The writer presents tentatively the following theory: a salt of any tautomeric compound reacts with an alkyl halide, or other reagent, and forms two derivatives, because the tautomeric salt is really a mixture of two tautomeric salts in equilibrium, each of which reacts with the alkyl halide in independent side reactions. This reaction may, in certain cases, be complicated by the simultaneous rearrangement of one of the reaction products into the other or some other product.

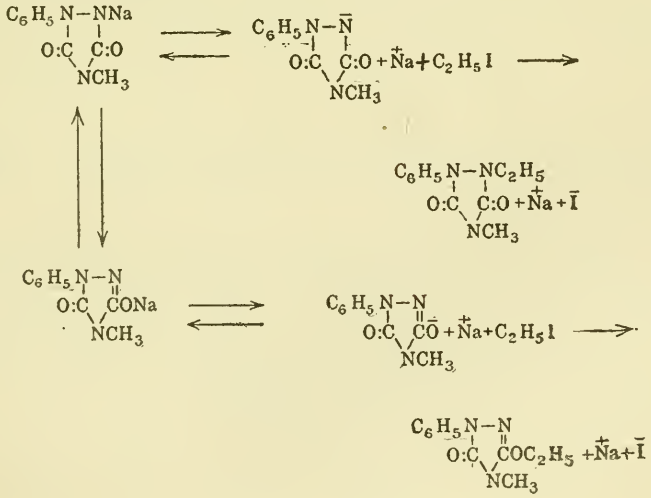
In order to test experimentally each of the above theories, the writer and his co-workers have studied quantitatively the alkylation of some salts of

tautomeric compounds, such as 1-phenyl-4-methylurazole. The fact that both the potassium salt and the silver salt of 1-phenyl-4-methylurazole yield a mixture of oxygen and nitrogen esters proves that Comstock's theory (I) can not be used as a general hypothesis.

Neither the oxygen derivative nor the nitrogen derivative rearranges into the other, nor does the ratio of the two derivatives change with change in time or temperature during the reactions. These facts show that Wheeler's theory (II) can not be used as a general explanation of such reactions.

The experimental evidence leads to the conclusion that only the urazole ions react with the alkyl halide, and that the reaction is one of the second order. The theories of Nef and of Michael demand that in such cases all salts should give the same ratio of oxygen and nitrogen esters. Since such is not the case, the theories of Nef and of Michael are not adequate to explain such reactions.

All of the quantitative data at hand seem to show that the equilibrium and reaction phenomena can be represented by the following scheme: The molecular forms of the salts are in equilibrium. The alkyl halide reacts only with the anions of the urazoles. The alkyl halide reacts as a molecule and not (1) through primary dissociation into alkyl and halide ions (theory of Bruyn and Steger); (2) through primary dissociation into a halogen acid and an unsaturated olefine or alkylidene residue (theory of Nef); nor (3) through primary union with the cation and formation of a complex cation, $RI.\overset{+}{M}$, which then reacts with the anion (theory of Euler). The evidence is in harmony with, but does not prove, the view that the alkyl halide unites with the anion and forms a complex unstable anion which decomposes at once into the ester and halide ions.



On the Composition of Toxicodendrol. (By S. F. Acree and W. A. Syme: The Journal of Biological Chemistry, vol. 2, p. 547.)—The investigation was undertaken to see if more light could be thrown on the chemical nature of toxicodendrol and the substances associated with it in the poison-ivy plant (*Rhus toxicodendron*). The crude material was made by Parke, Davis and Co., of Detroit, Michigan, according to special instructions sent to them, from 67.5 pounds of fresh leaves and flowers of the plant. The following is a summary of the results:

(1) Leaves and flowers of the poison-ivy plant were extracted with ether and the ether was removed by evaporation. In the residue the following substances were found and studied: gallic acid, fisetin, rhamnose, and a poisonous tar, gum, or wax.

(2) The lead compound of the poison is soluble in ether; this gives a means of separating the poisonous substance from the non-poisonous matter in one operation. It was found that a portion of the poisonous compound can be precipitated by lead acetate from a solution of the purified tar in 50 per cent alcohol.

(3) The poison is not volatile with the vapor of acetic acid, nor with the vapor of alcohol.

(4) The poisonous tar or wax was decomposed by acids and yielded gallic acid, fisetin, and rhamnose, showing the probable source of these compounds in the plant, and indicating that the poison is a complex substance of a glucoside nature.

(5) All cases of poisoning developed on Dr. Syme, in testing the poisonous properties of the different fractions, were easily cured with potassium permanganate.

(6) The following method is suggested for obtaining the poisonous substance from the plant: Extract the plant with alcohol, filter, and precipitate at once with lead acetate. Wash the precipitate, dry, and extract with ether in Soxhlet extractors (loosely filled). Combine the ether extracts, mix with water, and pass in hydrogen sulphide. Separate the water and the ether solution, and filter the latter. Wash the ether solution thoroughly by shaking with water, and then evaporate at a low temperature. The residue contains the toxicodendrol.

On Some Semicarbazide Derivatives of Isopropionic Acid, Benzoic Acid, and Benzenesulphonic Acid. (By S. F. Acree: American Chemical Journal, vol. 37, p. 361.)—In order to pursue some of the physical chemical problems connected with the semicarbazides and urazoles, a number of hydrazine, semicarbazide, and urazole derivatives of propionic acid, benzoic acid, and benzenesulphonic acid were made and studied.

Studies in Catalysis: the Rearrangement of Acetylhalogenaminobenzene Derivatives into Halogen Acetanilide Derivatives. (By S. F. Acree and J. M. Johnson: American Chemical Journal, vol. 37, p. 410.)—It was shown

that acetylhalogenaminobenzene derivatives rearrange in the presence of hydrochloric acid into halogen acetanilide derivatives according to the following reaction:

$$CH_3CONClC_6H_5 + H + \overline{Cl} \rightleftharpoons CH_3CONHCl_2C_6H_5 \rightarrow CH_3CONHC_6H_4Cl + \overset{+}{H} + \overline{Cl}$$

(or)

$$\frac{dx}{dt} = K_{trans}\, C_{hal} \times C_H \times C_{Cl} = K_{trans}\, C_{hal} \times C_H{}^2$$

in which K_{trans} is the reaction velocity, C_{hal} the concentration of the acetylhalogenaminobenzene derivative, and C_H and C_{Cl} the concentrations of the hydrogen and chloride ions. This work and researches on the hydrolysis of oximes prove that the three so-called laws of catalysis do not apply to all catalytic reactions, and show directly that (1) not all catalytic reactions have velocity constants directly proportional to the concentration of the catalyzer, and that (2) in some reversible reactions the equilibrium-point is changed by a change in the concentration of the catalyzer. The work further makes it clear that whereas in the catalysis of esters, amides, oximes, and cane-sugar in the presence of acids these substances, as weak bases, unite with a small amount of hydrogen ions and form complex cations which undergo transformation, yet in other catalytic reactions, such as the transformation of acetylchloraminobenzene, the substance really undergoing change is a neutral molecule formed by the union of the catalyzed substance and an anion and cation, or neutral catalyzer.

On the Constitution of Phenylurazole, III: A Contribution to the Study of Tautomerism. (By S. F. Acree: American Chemical Journal, vol. 38, p. 1.)—In a lengthy article involving the application of mathematics and physical chemical methods to the study of tautomerism, the following results were obtained:

(1) Experimental work and the application of the mass law show that the relative amounts of two stable derivatives formed by the reaction of a tautomeric compound, existing in two reacting forms in equilibrium, and another reagent depend upon (*a*) the relative reactivity of the two tautomeric forms toward the other reagent; (*b*) the ratio between the amounts of the two tautomeric forms when they are in constant equilibrium with each other; and (*c*) the rapidity of the change of each of these tautomeric forms into the other as the equilibrium between them is disturbed. In some cases the reaction may be complicated by the rearrangement of one, or each, of the tautomeric derivatives into the other, or some other products.

(2) Various phases of the equilibrium condition existing in a solution of a tautomeric acid or base, or the salts, have been studied theoretically, by the application of the mass law, and experimentally. For example, it was

shown that the affinity constant, K, of a tautomeric amide is expressed by the equation,

$$\frac{H \times (Cki + Cei)}{(Ck + Ce)} = \frac{(K_2 + K_1K_3)}{1 + K_3} = K$$

in which H is the concentration, in gram molecules per liter, of the hydrogen ions, *Cki* the concentration of the anions of the keto form, *Cei* the concentration of the anions of the enol form, *Ck* that of the molecular keto form, *Ce* that of the molecular enol form, K_1, the affinity constant of the keto form, K_2 the affinity constant of the enol form, and K_3 the ratio of the keto form to the enol form.

(3) The conditions under which normal and abnormal hydrolysis of salts of tautomeric compounds can be detected have been discussed.

(4) A large number of derivatives of phenylurazole have been made and studied qualitatively and quantitatively, especially in the light of the theories of tautomeric substances.

Bancroft, Wilder D., Cornell University, Ithaca, New York. Grant No. 411. *Systematic study of alloys.* (For previous reports see Year Book No. 2, p. xxix; Year Book No. 3, p. 104; Year Book No. 4, pp. 133–134, and Year Book No. 5, p. 141.) $1,000.

The constitution of the copper-tin bronzes has been determined for temperatures above 219° and an account has been published in the Journal of Physical Chemistry, volume 10, page 630 (1906). There are still some unexplained heat changes at 218° and at 182°. When these have been worked out, the results obtained during the last five years will be presented as a monograph.

The constitution of the aluminum-copper alloys has been determined and an account has been published in the Journal of Physical Chemistry, volume 11, page 425 (1907). There are 6 series of solid solutions and 1 compound, $CuAl_2$. The β crystals are instable below 566° and the δ crystals below 570°.

An account of work on the tensile strength and ductility of cast aluminum bronzes has been published in the Journal of Physical Chemistry, volume 11, page 461 (1907). The maximum strength of the aluminum-rich alloys is 28,000 pounds per square inch and of the copper-rich alloys over 100,000 pounds per square inch. A ductility of 50 to 60 per cent is obtained with alloys containing 92 to 95 per cent copper. The maximum strength does not occur at a boundary curve. Annealing increases the ductility of the aluminum-rich alloys, but decreases that of the copper-rich alloys. No explanation has been found for this difference in behavior.

A study has been made of the electrolytic corrosion of the aluminum bronzes, and this work is nearly ready for publication. The work on the constitution of the iron-carbon alloys has proceeded very slowly, and the

only progress has been in improving the methods of attack. If no new difficulties arise, another year should bring definite results. Further experiments have been made on the tensile strength of aluminum-zinc castings. The results with the zinc-rich alloys are so discordant that it has been necessary to make a special study of the casting of pure zinc. This work is now under way. Owing to conditions beyond the control of Dr. Bancroft no further work has been done on the constitution of the miscellaneous zinc alloys.

Baxter, Gregory P., Harvard University, Cambridge, Massachusetts. Grant No. 451. *Researches upon atomic weights.* (For previous reports see Year Book No. 3, p. 105; Year Book No. 4, pp. 149, 150, and Year Book No. 5, pp. 147–149.) $1,000.

The following investigations were carried on under Professor Baxter's direction:

The analysis of iodine pentoxide, begun last year with the assistance of Mr. George S. Tilley, was continued. Iodic acid, made by the action of pure fuming nitric acid upon the purest iodine in quartz vessels, was purified by crystallization in quartz vessels. Portions of about 10 grams of the acid were carefully dehydrated in a platinum boat in a current of dry air, the temperature finally reaching 240° C., and the resulting iodine pentoxide was weighed. Then it was dissolved in water, reduced in dilute nitric acid solution by means of hydrazine, and finally it was precipitated in thirtieth normal solution with a nitric acid solution of a weighed amount of silver, about 0.2 milligram in excess of the necessary quantity being used. This excess of silver was determined gravimetrically after evaporation of the entire filtrate to small volume. It was found impossible to use sulphurous acid as the reducing agent, owing to the occlusion of silver sulphate.

The ratio of silver to iodine pentoxide was found in 7 experiments to be 0.646221, 0.646210, 0.646218, 0.646194, 0.646227, 0.646209, 0.646204; average 0.646212. Assuming the iodine pentoxide to have been pure and using the ratio of silver to iodine already determined by Baxter, 0.848843, the atomic weight of silver referred to oxygen 16.000 is calculated to be 107.837, which is undoubtedly a minimum value. However, the iodine pentoxide was found to contain 0.0023 per cent of moisture. If this correction is applied, the atomic weight of silver becomes 107.847. This result is lower than was to be expected and the problem is being further investigated.

Dr. Edward Mueller continued the investigation upon silver chromate commenced last year by Dr. M. A. Hines. Silver chromate was precipitated by the addition of a dilute solution of silver nitrate to a dilute neutral solution of either potassium or ammonium chromate. After being heated for some time at 225° C., weighed portions of this salt were dissolved in nitric acid, reduced with either sulphurous acid or hydrazine sulphate, and the silver was precipitated with either hydrochloric or hydrobromic acid. Then

the precipitated silver halide was collected and weighed. It was found that at 225° all moisture was not eliminated from the silver chromate, while a higher temperature produced incipient decomposition; hence a correction for the moisture retained by the salt at 225° was determined. Assuming the following atomic weights, Ag = 107.93, Cl = 35.473, Br = 79.953, the ratio Ag_2CrO_4: 2AgCl gives as the molecular weight of silver chromate the value 331.915 and the ratio Ag_2CrO_4: 2AgBr the value 331.928, with an average value 331.922. No regular differences in the results with material prepared from potassium and ammonium chromate could be observed. If silver is taken at 107.930 referred to oxygen 16.000, the atomic weight of chromium appears to be 52.06, while if silver is assumed to be 107.88 the atomic weight of chromium is 52.01. This investigation is being continued by the analysis of silver dichromate.

With Mr. Grinnell Jones a revision of the atomic weight of phosphorus was begun by analysis of tri-silver phosphate. This salt was prepared by precipitating a dilute solution of silver nitrate with solutions of di-metallic or tri-metallic phosphates of sodium and ammonium. Portions of the carefully washed salt were dried in a current of pure dry air at about 400° and were weighed. Next they were dissolved in nitric acid and the silver was precipitated and determined either as silver bromide or as silver chloride. The different samples of material all gave essentially the same result, with the exception of the precipitate formed with tri-sodium phosphate which proved to contain large amounts of sodium, showing that slightly different degrees of alkalinity or acidity during the precipitation of the tri-silver phosphate produce no tendency for occlusion of other salts of silver and phosphoric acid. Two corrections must be applied to the result—one for the small quantity of moisture retained by the silver phosphate, and the other for slight decomposition owing to the action of heat or light during the drying. These corrections are probably very small and in an opposite direction. Until they are accurately determined it is premature to state the results of the work.

Parallel with the work upon phosphorus, Mr. F. B. Coffin carried on the analysis of tri-silver arsenate by similar methods. The arsenate was formed by adding dilute solutions of di-metallic or tri-metallic arsenates of sodium and ammonium to dilute silver nitrate solution. The salt was washed, and dried at 250° in a current of pure dry air. Then, after being weighed, it was analyzed either by heating in a quartz tube in a current of pure hydrochloric acid gas until all arsenic was expelled, or by solution in nitric acid and precipitation with either hydrochloric or hydrobromic acid. While all three methods gave essentially identical results with the same sample, different samples of material indicate slight differences in composition with varying conditions of precipitation. These differences are still under investigation. The salt undoubtedly retains traces of water when dried at 250°, and a correction for this moisture remains to be determined. Furthermore,

as in the case of silver phosphate, the dried salt contained a slight residue insoluble in dilute nitric acid. Preliminary determinations have shown, however, that the composition of this insoluble residue is very close to that of tri-silver arsenate, so that no appreciable correction is involved. At the present stage of the investigation no certain results can be given.

As a check upon the value 54.96 (Ag = 107.93) for the atomic weight of manganese, found by Dr. M. A. Hines (see Jour. Amer. Chem. Soc., vol. 28, p. 1560, 1906), Mr. Hobart H. Willard attempted the analysis of silver permanganate. This salt, even when very pure, proved entirely unsuited for accurate work, on account of the ease with which it is decomposed. In the hope that the loss of oxygen could be brought to a constant point by ignition in an atmosphere of hydrogen, with the formation of the mixture of metallic silver and manganous oxide which may be represented by the formula Ag.MnO, many reductions of this sort were carried out. Then the silver content of the residues was determined, after solution in nitric acid. These preliminary experiments, which consumed much time and energy, showed that neither platinum nor quartz could be used as a containing vessel, since at temperatures high enough to insure complete reduction, the former alloys with the silver and the latter is attacked by the oxide. As a last resort boats of metallic copper were employed, the boats being dissolved in nitric acid at the same time as the residue. This method gives indications of success.

With Mr. John H. Wilson the atomic weight of lead was investigated by the analysis of lead chloride. Very pure specimens of this salt were prepared for analysis by fusion in a current of dry hydrochloric acid gas. Then, after solution in water, the chloride was titrated against a weighed equivalent amount of the purest silver. Finally the precipitate of silver chloride was collected and weighed. From both ratios, $PbCl_2$: 2Ag and $PbCl_2$: 2 AgCl, the atomic weight of lead is found to be 207.19 if the atomic weight of silver is assumed to be 107.930. With silver at 107.88, the atomic weight of lead becomes 207.09. This result is nearly two-tenths of a unit higher than the generally accepted value.

Jones, Harry C., Johns Hopkins University, Baltimore, Maryland. Grant No. 387. *Continuation of investigations on absorption spectra of certain salts in aqueous and non-aqueous solvents.* (For previous reports see Year Book No. 2, p. xxx; Year Book No. 3, p. 106; Year Book No. 4, pp. 151, 152, and Year Book No. 5, pp. 149, 150.) $1,000.

The problem of hydration in aqueous solution has been studied during the past year from three different standpoints:

(1) The relation between the dissociation of electrolytes as measured by the freezing-point, and by the conductivity methods.

(2) The effect of one salt, with a given hydrating power, on the hydrating power of another salt present in the same solution. The object of this line of

work was to test the applicability of the law of mass action to the problem of hydration.

(3) The study of the absorption spectra of solutions as throwing light directly upon the hydration of the dissolved salt, and upon the change in hydration produced by the presence of a second salt. The absorption spectra of solutions of salts in such non-aqueous solvents as methyl alcohol, ethyl alcohol and acetone, on the addition of varying amounts of water, show clearly the formation of hydrates and the change in their composition.

The dissociation of 10 salts and 3 acids has been measured by the freezing-point and by the conductivity methods. Hydration, or combination with the solvent, should affect the freezing-point method to a greater extent than the conductivity method. This will be seen at once, if we consider that freezing-point lowering is directly proportional to the number of molecules of water present acting as solvent. If a part of the water is in combination, this would affect the freezing-point lowering proportionally, while the conductivity would be affected to a much smaller extent.

The dissociation of solutions of concentrations varying from normal to one one-hundredth normal, of the following substances, was measured by both the freezing-point and the conductivity methods: Sodium bromide, barium nitrate, barium bromide, barium iodide, calcium chloride, cobalt nitrate, nickel nitrate, copper chloride, copper nitrate, aluminium chloride, hydrochloric acid, nitric acid, and sulphuric acid.

The results show that the dissociation of the salts as measured by the freezing-point method is uniformly greater than as measured by conductivity, just as would be expected from the hydrate theory.

The effect of one salt on the hydrating power of another salt has been studied fairly extensively—the following pairs of compounds having been brought within the scope of this investigation: Potassium chloride and calcium chloride; calcium chloride and magnesium chloride; calcium chloride and strontium chloride; potassium chloride and ammonium chloride; ferric chloride and aluminium chloride; lithium bromide and sodium bromide; calcium nitrate and magnesium nitrate; magnesium nitrate and strontium nitrate; and calcium nitrate and calcium chloride.

The dilutions used ranged from two-thousandths to 3.5 normal.

The freezing-point lowerings and the conductivities of all of the solutions of the above substances, separately and when mixed, were measured, and the results obtained under these widely different conditions compared with one another.

Careful quantitative measurements showed that the effect of one salt with a given hydrating power, on the hydrating power of a second salt, was in accord with the law of mass action.

The effect of one salt on the dissociation of another salt with a common ion was investigated, using such pairs of compounds as potassium chloride

and ammonium chloride. Some interesting and important results were obtained in connection with the influence of temperature on the effect of one salt on the dissociation of another salt with a common ion.

The spectroscopic investigation which is now in progress is a continuation of the work of Jones and Uhler. It has had to do with an enlargement of the spectrograph so as to include still longer wave-lengths than were recorded in the earlier work. A study has been made of various photographic films, to ascertain which would give the most satisfactory records over the greatest range of wave-lengths. Various sources of illumination have been investigated to see which would give the best results over the widest range. One source has been found which apparently fulfills the desired conditions very satisfactorily.

The absorption spectra of solutions of such substances as cobalt chloride, cobalt bromide, copper chloride, and copper bromide, in the alcohols, acetone, etc., keeping the *total amount of the colored salt constant,* and varying the concentration by the addition of more or less of the solvent or solvents, are being photographed.

The same line of work will also be extended to solutions of such substances as ferric chloride, ferric citrate, ferric sulphocyanate, cobalt bromide, cobalt acetate, cobalt sulphocyanate, copper acetate, chromic acid, and the like, in water as the solvent, using as wide a range of dilution as is practical.

The absorption spectra of a number of the above-named substances are also being studied in pure non-aqueous solvents, and in such solvents to which varying amounts of water are added.

The effect of rise in temperature on the absorption spectra of solutions of colored salts, to which already some attention has been given, will be studied much more thoroughly as this investigation proceeds.

The absorption spectra of solutions of different concentrations of a given salt, containing the same number of colored particles in the path of the beam of light, are also being photographed.

Morse, H. N., Johns Hopkins University, Baltimore, Maryland. Grant No. 412. *On the measurement of osmotic pressure.* (For previous reports see Year Book No. 2, p. xxx; Year Book No. 3, p. 108; Year Book No. 4, pp. 152, 153, and Year Book No. 5, pp. 150–153.) $1,800.

The work completed during the past year under grants from the Carnegie Institution of Washington, has been described in a series of four papers. These appeared in the April, May, June, and August numbers of the American Chemical Journal for 1907, under the following titles:

The osmotic pressure and the depression of the freezing-point of solutions of glucose.
The osmotic pressure of cane-sugar solutions in the vicinity of the freezing-point of water.
The osmotic pressure of glucose solutions in the vicinity of the freezing-point of water.
The osmotic pressure of cane-sugar solutions in the vicinity of 5°.

The range of temperatures over which the measurements of the pressure of glucose solutions were made, in the first instance, was from 22.1° to 26.9°, while the concentration of the solutions varied, by tenths, from 0.1 to 1.0 weight-normal. At these temperatures, the solutions of glucose exhibited pressures which were characterized in the following words:

"It is clear, as it was in the case of cane-sugar, that *glucose in aqueous solution, at temperatures in the vicinity of 20°, exerts an osmotic pressure equal to that which a molecular-equivalent quantity of a gas would exert if its volume were reduced, at the same temperature, to that of the solvent in the pure state.* This rule holds equally well throughout all the concentrations whose pressures we have measured, and the deviations from it do not exceed the known but unavoidable experimental errors of the work."

The justification for the conclusion stated above will be found in table 1, which gives a summary of the experimental results.

TABLE 1.—*Determination of the Osmotic Pressure of Glucose. Series I, 1906. Summary of Results.*

Weight normal concentration.	No. of experiment.	Temperature of solution (degrees).	Observed osmotic pressure (atmospheres).	Theoretical gas pressure at same temperature (atmospheres).	Difference between osmotic and gas pressure.	Molecular weight calculated from osmotic pressure.	Mean molecular weight for each concentration.
0.1	1	24.10	2.39	2.42	—0.03	181.40	180.62
"	2	25.10	2.42	2.43	—0.01	179.83	
0.2	1	24.10	4.76	4.85	—0.09	181.77	181.94
"	2	24.93	4.77	4.86	—0.09	182.10	
0.3	1	22.20	7.12	7.22	—0.10	181.38	181.06
"	2	23.48	7.17	7.25	—0.08	180.73	
0.4	1	26.90	9.70	9.78	—0.08	180.21	180.62
"	2	26.60	9.65	9.77	—0.12	181.02	
0.5	1	21.86	12.07	12.03	+0.04	178.12	179.35
"	2	24.17	12.00	12.12	—0.12	180.57	
0.6	1	22.57	14.56	14.46	+0.10	177.62	179.62
"	2	22.40	14.32	14.40	—0.08	180.42	
"	3	22.30	14.29	14.45	—0.16	180.83	
0.7	1	22.26	16.82	16.85	—0.03	179.18	179.63
"	2	25.43	16.96	17.04	—0.08	179.55	
"	3	22.70	16.75	16.88	—0.13	180.16	
0.8	1	23.00	19.27	19.31	—0.04	179.16	179.76
"	2	23.28	19.16	19.33	—0.17	180.39	
"	3	23.64	19.25	19.35	—0.10	179.73	
0.9	1	23.80	21.64	21.80	—0.16	179.87	179.99
"	2	22.58	21.49	21.70	—0.21	180.49	
"	3	23.10	21.63	21.74	—0.11	179.60	
1.0	1	22.20	24.12	24.08	+0.04	178.46	179.04
"	2	22.60	24.00	24.11	—0.11	179.60	
"	3	22.10	24.03	24.07	—0.04	179.07	

H = 1. Mol. Wt. Glucose = 178.74. Mean Mol. Wt. 180.08.

A second conclusion which was drawn from the results involved the question of the hydration of glucose in solution. The pressures observed were found to be quite strictly proportional to the weights of glucose dissolved in the unvarying mass of the solvent. This led to the conviction that, "in the

vicinity of 20°, glucose in aqueous solution can not be hydrated." A similar conclusion had already been reached with respect to the state of cane-sugar in aqueous solution, namely, that, in the vicinity of 20°, it also is anhydrous.

In the second paper it was shown that whereas in the vicinity of 20° osmotic and gas pressures are about equal, in the vicinity of the freezing-point of water the osmotic pressures of cane-sugar solutions are notably in excess of the calculated gas pressures; also that the divergence between the two tends, in general, to increase with concentration. Table 2 is introduced to illustrate these relations.

TABLE 2.—*Cane-sugar. Mean Values for Each Concentration. Series III.*

Weight-normal concentration.	Temperature (degrees).	Calculated gas pressure.	Osmotic pressure.			Ratio of osmotic to gas pressure.		
			If all loss in rotation is ascribed to inversion.	If all loss in rotation is ascribed to dilution.	If half the loss in rotation is ascribed to dilution.	If all loss in rotation is ascribed to inversion.	If all loss in rotation is ascribed to dilution.	If half the loss in rotation is ascribed to dilution.
0.1	0.24	2.23	2.40	2.45	2.44	1.077	1.099	1.092
0.2	0.26	4.46	4.76	4.82	4.80	1.067	1.081	1.075
0.3	0.22	6.69	7.03	7.23	7.16	1.051	1.081	1.071
0.4	0.24	8.92	9.28	9.45	9.40	1.040	1.060	1.054
0.5	0.21	11.14	11.61	11.95	11.85	1.042	1.073	1.064
0.6	0.22	13.37	13.99	14.40	14.25	1.046	1.077	1.066
0.7	0.21	15.60	16.51	16.95	16.81	1.058	1.087	1.078
0.8	0.22	17.83	18.99	19.52	19.33	1.060	1.095	1.085
0.9	0.27	20.06	21.60	22.35	22.13	1.077	1.115	1.103
1.0	0.25	22.28	24.00	25.13	24.78	1.077	1.127	1.112

In a third paper an account was given of the pressures which glucose solutions had been found to exert in the vicinity of the freezing-point of water. These also were considerably above the calculated gas pressures, but the divergence between the two was less than in the case of equivalent cane-sugar solutions at the same temperature. Moreover, the pressures of glucose solutions in the neighborhood of 0° were found, like those of both glucose and cane-sugar in the vicinity of 20°, to be proportional to the weight of the sugar which is dissolved in the fixed mass of water, which appears to prove that, even at 0°, glucose in solution is in the anhydrous condition. The same conclusion was drawn from the fact that the molecular depression of the freezing-point of weight-normal glucose solutions was found to be a constant value. Table 3 gives a summary of the results.

Another matter which was brought out in the third paper is the relation which has been found to hold for both glucose and cane-sugar solutions between the deviations of osmotic from gas pressures on the one side, and, on the other, the deviations of the observed molecular depressions of the freezing-points from 1.85, the calculated molecular depression of the freezing-

TABLE 3.—*Glucose. Results for Each Concentration.*

Weight-normal concentration.	Temperature (degrees).	Osmotic pressure (atmospheres).	Calculated gas pressure (atmospheres).	Molecular osmotic pressure (atmospheres).	Molecular gas pressure (atmospheres).	Ratio of osmotic to gas pressure.	Ratio of Δ to 1.85.
0.1	0.26	2.40	2.23	23.97	22.28	1.074	1.038
0.2	0.13	4.65	4.45	23.24	"	1.045	"
0.3	0.22	7.01	6.68	23.38	"	1.050	"
0.4	0.17	9.30	8.91	23.24	"	1.044	"
0.5	0.21	11.65	11.14	23.29	"	1.046	"
0.6	0.10	14.01	13.36	23.34	"	1.048	"
0.7	0.07	16.37	15.59	23.38	"	1.050	"
0.8	0.13	18.77	17.82	23.45	"	1.053	"
0.9	0.16	21.25	20.05	23.60	"	1.060	"
1.0	0.17	23.59	22.28	23.59	"	1.057	"
1	2	3	4	5	6	7	8

Ratio of Δ to 1.84 = 1.044. Mean ratio = 1.052.

point of water. The conclusion which was reached with respect to this relation was stated in the following words:

It appears to have been established by the results published in this paper and the preceding one that, in the vicinity of the freezing-point of the solvent, both glucose and cane-sugar solutions exert osmotic pressures which differ from the calculated gas pressures in about the same degree that the observed depressions of the freezing-points of such solutions differ from those which are calculated by means of the value 1.85.

In view of this conclusion, it is now important to measure, in the vicinity of 0°, the osmotic pressures of the solutions of some substance of which the observed molecular depression of the freezing-point is approximately 1.85. It is to be anticipated that such solutions, in the vicinity of the freezing-point of water, will be found to exhibit osmotic pressures more in accord with the calculated gas pressures than are those of glucose and cane-sugar. We shall undertake this as soon as we have succeeded in suppressing dilution in the cell.

Attention is called to table 4, which brings out clearly the mutual relations of glucose and cane-sugar with respect to the osmotic pressures and freezing-points of their equivalent solutions.

If we represent by

P, the osmotic pressure of glucose,

P_1, the osmotic pressure of cane-sugar,

Δ, the observed molecular depression of the freezing-point of glucose,

Δ_1, the observed molecular depression of the freezing-point of cane-sugar,

R, the ratio of osmotic to gas pressure for glucose,

R_1, the ratio of osmotic to gas pressure for cane-sugar,

then proportions, such as the following, should be found to hold approximately:

1. $P : P_1 :: \Delta : \Delta_1$; 2. $R : R_1 :: \Delta : \Delta_1$; 3. $R : R_1 :: \frac{\Delta}{1.85} : \frac{\Delta_1}{1.85}$; etc.

How they do hold for the proportion $P : P_1 : : \Delta : \Delta_1$ (and consequently for all other proper methods of comparison) is shown in table 4. Exact agreement between the calculated and experimental values is not to be expected, owing to differences of temperature, and the divergences between them should increase with the concentration.

TABLE 4.

Weight-normal concentration.	P, osmotic pressure of glucose.	P_1, osmotic pressure of cane-sugar.	Δ observed molecular depression of freezing-point of glucose.	Δ_1 molecular depression of freezing-point of cane-sugar.	
				Calculated.	Observed.
0.1	2.40	2.44	1.92	1.95	1.95
0.2	4.65	4.80	"	1.98	1.96
0.3	7.01	7.16	"	1.96	1.95
0.4	9.30	9.40	"	1.94	1.96
0.5	11.65	11.85	"	1.95	1.97
0.6	14.01	14.25	"	1.95	1.98
0.7	16.37	16.81	"	1.97	1.99
0.8	18.77	19.33	"	1.98	2.02
0.9	21.25	22.13	"	2.00	2.03
1.0	23.59	24.78	"	2.02	2.07

The excess of osmotic over gas pressure in the vicinity of 0°, while the two were found to be in substantial agreement in the neighborhood of 20°, made it desirable to determine the pressures of both cane-sugar and glucose solutions at several intermediate temperatures, in order to ascertain just where, and at what rate or rates, the divergences observed at low temperatures disappear. The intervals selected for this purpose are 5,° 10°, and 15°.

The work upon cane-sugar solutions at 5° has been completed, and was described in the fourth paper mentioned at the beginning of this report. A summary of the results is given in table 5 on p. 192.

There is very little evidence to be discovered in the pressures exerted by cane-sugar in solution at 0°, at 5°, and in the vicinity of 20°, of any considerable temperature coefficient for osmotic pressure such as that for gases. It would, however, be premature to conclude from this that osmotic pressure, even in the case of cane-sugar, does not obey the law of Gay-Lussac; since, as the author has pointed out elsewhere, it is still possible that the causes which produce abnormal pressures at 0° and similarly abnormal depressions of the freezing-points, disappear gradually with rising temperature, and at a rate which effectually masks the temperature coefficient of the osmotic pressure. It is to be anticipated that much clearer evidence upon this important question will be secured by investigating the osmotic pressure of substances the molecular depressions of whose freezing-points are more nearly equal to the calculated value 1.85 than are those either of cane-sugar or of glucose.

Drs. J. C. W. Frazer, B. F. Lovelace, W. W. Holland, F. M. Rogers, and P. B. Dunbar have cooperated with the author in the work here reported.

TABLE 5.—*Cane-sugar. Series IV.*

Weight-normal concentration.	Temperature of solution (degrees).	Osmotic pressure.			Calculated gas pressure for same temperature.
		Observed (uncorrected for loss in rotation).	If all loss in rotation is ascribed to inversion.	If half the loss in rotation is ascribed to dilution.	
0.1	4.89	2.40	2.39	2.41	2.27
0.2	5.32	4.75	4.73	4.77	4.55
0.3	4.50	7.07	7.03	7.10	6.79
0.4	4.50	9.43	9.33	9.49	9.05
0.5	4.79	11.82	11.74	11.90	11.33
0.6	5.54	14.43	14.30	14.52	13.63
0.7	4.45	16.79	16.61	16.92	15.85
0.8	4.41	19.31	19.10	19.47	18.10
0.9	4.78	22.15	21.89	22.33	20.39
1.0	4.46	24.53	24.23	24.75	22.63

Weight-normal concentration.	Temperature of solution (degrees).	Molecular osmotic pressure.			Molecular gas pressure.
		Observed (uncorrected for loss in rotation).	If all loss in rotation is ascribed to inversion.	If half the loss in rotation is ascribed to dilution.	
0.1	4.89	24.00	23.89	24.10	22.66
0.2	5.32	23.75	23 62	23.83	22.73
0.3	4.50	23.57	23.43	23.67	22.63
0.4	4.50	23.57	23.34	23.73	22.64
0.5	4.79	23.64	23.47	23.80	22.66
0.6	5.54	24.05	23.83	24.20	22.72
0.7	4.45	23.99	23.73	24.18	22.63
0.8	4.41	24.14	23.87	24.33	22.63
0.9	4.78	24.61	24.33	24.81	22.66
1.0	4.46	24.53	24.23	24.75	22.63

Weight-normal concentration.	Temperature of solution (degrees),	Ratio of osmotic to gas pressure.		
		Observed (uncorrected for loss in rotation).	If all loss in rotation is ascribed to inversion.	If half the loss in rotation is ascribed to dilution.
0.1	4.89	1.057	1.053	1.062
0.2	5.32	1.045	1.040	1.049
0.3	4.50	1.042	1.036	1.046
0.4	4.50	1.042	1.031	1.049
0.5	4.79	1.043	1.036	1.051
0.6	5.54	1.059	1.049	1.066
0.7	4.45	1.060	1.049	1.068
0.8	4.41	1.067	1.056	1.076
0.9	4.78	1.086	1.074	1.095
1.0	4.46	1.084	1.071	1.094

Noyes, Arthur A., Massachusetts Institute of Technology, Boston, Massachusetts. Grant No. 413. *Researches upon* (1) *Electrical conductivity of aqueous solutions at high temperatures;* (2) *Electrical transference determinations in aqueous solutions.* (For previous reports see Year Book No. 2, p. xxxi; Year Book No. 3, p. 109; Year Book No. 4, p. 154, and Year Book No. 5, p. 153.) $2,000.

These researches have now been in progress under the auspices of the Carnegie Institution of Washington, for a period of five years. The methods employed and the results thus far attained have been fully described in Publication No. 63 of the Institution—a monograph of 352 pages, in twelve parts, entitled "The Electrical Conductivity of Aqueous Solutions," which was issued in September, 1907. At the close of that publication, in part XII, will be found a comprehensive but concise summary of the work which has been accomplished. It may, however, be mentioned that the work executed during the past year has consisted mainly in the study of the conductivity and ionization-relations of a number of important acids between 18 and 306° and in the further development of the apparatus and method for extending the measurements with all classes of substances to the critical temperature (375°) and above. Progress has also been made in the research upon electrical transference in aqueous solution, which has for its object the determination of the extent to which the ions are hydrated. Conclusive evidence has already been obtained that each equivalent of sodium ion carries not less than 2 mols of water.

Richards, Theodore W., Harvard University, Cambridge, Massachusetts. *Investigations concerning the values of the atomic weights and other physico-chemical constants.* Grant No. 414. (For previous reports see Year Book No. 2, p. xxxii; Year Book No. 3, p. 112; Year Book No. 4, p. 155, and Year Book No. 5, p. 154.) $2,500.

All the available time, instead of being devoted to experimental work, was spent in codifying and publishing nine papers issued as parts of publications Nos. 69 and 76 of the Institution or whose titles are given in the bibliography in this volume (pp. 46-54). These papers give in full the results of the investigations numbered 1, 2, 3, 4, 6, and 8 in the last report. Further work upon the investigations numbered 5 and 7 and others will be prosecuted with the help of able assistants during the coming winter.

ENGINEERING.

Goss, W. F. M., Purdue University, Lafayette, Indiana. Grant No. 425. *An investigation to determine* (1) *the value of superheated steam when employed in single-expansion locomotives;* (2) *the performance of compound locomotives when served with saturated steam and when served with superheated steam.* $4,000.

Operations under this grant have thus far been directed to a determination of the value of superheated steam when employed in single-expansion locomotives. They have been in cooperation with the authorities of Purdue University, which has made available for the work its locomotive-testing laboratory, together with all apparatus therein contained. In response to plans which had been outlined previous to the announcement of the grant, the Purdue experimental locomotive had, by the courtesy of the American Locomotive Company, been equipped with a Cole superheater by which the steam delivered to the locomotive cylinders is heated to a temperature which is from 150° to 200° higher than that of the water from which it is generated. Results obtained from this locomotive prior to its being equipped with a superheater supply an acceptable base from which to estimate the advantages to be derived from the presence of the superheater. The grant became available January 1, 1907, and as all necessary equipment was in readiness, no time was lost in starting the work. Up to July 1, twenty tests had been run and it is expected that the whole series involving the present superheater will be completed before the end of the summer, after which a new superheater having other proportions will be installed, in anticipation of a second series of tests.

While the work of the computing-room is necessarily behind that of the laboratory, it has been possible to prepare a preliminary statement defining the performance of the superheater, and giving a forecast of the economic results to be expected from its use. This was in the form of a paper entitled "Notes concerning the performance of the Cole superheater as applied to the Purdue University locomotive," presented at the spring meeting of the American Society of Mechanical Engineers.

Throughout the progress of the work the laboratory has been fortunate in having the cooperation of the technologic branch of the U. S. Geological Survey, which has supplied two skilled investigators, who have had special charge of all work relating to analyses and tests to determine calorific values of fuels used, and of the ash, cinders, sparks, and smoke-box gases developed by the tests.

GEOLOGY.

Chamberlin, T. C., University of Chicago, Chicago, Illinois. Grant No. 415. *Study of fundamental problems of geology.* (For previous reports see Year Book No. 2, pp. 261–270; Year Book No. 3, pp. 195–258; Year Book No. 4, pp. 171–190, and Year Book No. 5, pp. 166–172.) $6,000.

The work of Dr. Chamberlin and his collaborators, Dr. F. R. Moulton, Dr. A. C. Lunn, and Dr. Julius Stieglitz, has followed closely the lines set forth in Year Book No. 5, pages 166 to 172. Much time has been occupied with certain subsidiary inquiries which have arisen in the development of the leading subjects, and which were found to be of essential importance in their bearings on them. Some of these have involved unexpected difficulties of treatment and have caused great labor, but in the end they have given satisfactory results. These auxiliary studies will add two or three more papers to the series outlined in the report of last year. In the expectation of the early publication of the whole series of studies, it is not thought advisable to enter upon details here.

Washington, Henry S., Locust, New Jersey. Grant No. 95. *Chemical investigations of igneous rocks.* (For previous reports see Year Book No. 3, p. 113; Year Book No. 4, p. 158, and Year Book No. 5, p. 172.) $1,200.

The year has been chiefly devoted to the further chemical analysis and study of the igneous rocks collected in 1905, 25 new analyses and many determinations of minor constituents to complete the older ones having been made. A paper entitled "The titaniferous basalts of the Western Mediterranean" was read before the Geological Society of London and published in its Quarterly Journal, and the extended discussion of the chemical conditions which control the formation of leucite in igneous rocks was completed and published in the Journal of Geology. A paper giving the results of the study of the volcanic rocks of Catalonia, with 7 analyses, was published in the American Journal of Science, and another describing the volcanoes and igneous rocks of the island of Linosa, with 6 analyses, is to appear in the Journal of Geology this winter. Dr. Washington is at present particularly engaged in a study of the igneous rocks of the island of Pantelleria, of which 15 analyses have been made. This will probably appear during the winter. In conjunction with Dr. F. E. Wright, of Washington, who undertakes the optical side of the investigation, the peculiar amphibole of Linosa and the closely similar kaersutite of Greenland are being studied, a complete analysis of each having been made. The material for the latter was kindly furnished

by Prof. N. V. Ussing, of Copenhagen. The results of this will appear this year in the American Journal of Science. An analysis was made of the trachyte of Monte Axpe, near Bilbao, Spain, the material having been furnished by Señor Fernandez-Navarro, of Madrid. A short note is to be published concerning this, the full description of the occurrence being undertaken by Señor Navarro. It is purposed, during the coming year, to study the igneous rocks collected in Sardinia, as well as those from the volcanoes of Agde and Montpellier for comparison, material from these last having been kindly sent to Dr. Washington by Professor Lacroix.

It is estimated that about 30 analyses remain to be made, and that the investigation of the comagmatic region will not be completed in less than a year.

GEOPHYSICAL RESEARCH.

Adams, F. D., McGill University, Montreal, Canada. Grant No. 335. *Continuation of investigation into the flow of rocks.* (For previous reports see Year Book No. 2, p. xxxiv; Year Book No. 3, p. 119; Year Book No. 4, pp. 230, 231, and Year Book No. 5, pp. 174, 175.) $1,500.

The work of measuring the amount of internal friction developed in certain rocks when under conditions of very slow deformation, which occupied the greater part of last year, was continued in the early part of the present year. It was interrupted by the burning of the engineering building of McGill University, in which the large 100-ton testing-machine employed in this work was set up. This machine, however, was not injured by the fire, and the work will be resumed upon the completion of the new engineering building, which is now in course of erection.

The work of measuring the cubic compressibility of rocks by Richards & Stull's method, which is being carried on in conjunction with Professor McKergow, was also continued during the past year. Certain experimental difficulties, however, not having been as yet overcome, satisfactory results have not yet been secured. The solution of these difficulties is looked for during the coming year.

The experimental work carried on during the past year was chiefly along two lines:

(1) The deformation of the various rocks which are under examination, at much higher temperatures than those which it had been possible to formerly attain. Temperatures up to 1,000° C., combined with great pressures, have been secured, and the deformation of diabase, essexite, and other basic crystalline rocks has been studied under these conditions.

(2) An investigation has been commenced with a view to determining the depth beneath the earth's surface of the zone of flow in the case of granite and Solenhofen lithographic stone respectively. This consists in submitting

columns of these rocks, through which small holes have been bored in certain directions, and which have then been placed within heavy steel collars, to pressures representing depths of from 5 to 50 miles below the surface of the earth.

This investigation, dealing as it does with the question of the depth beneath the earth's surface at which cavities when opened will be closed again by the flow of the surrounding rock into them, is one which has a direct bearing on the problem of the possible extent in depth of mineral veins, as well as on various problems which present themselves in driving deep tunnels.

The investigation has already furnished very interesting results, but must be carried farther before these can be definitely stated.

Becker, George F., U. S. Geological Survey, Washington, District of Columbia. Grant No. 226. *Experiments on elasticity and plasticity of solids.* (For previous reports see Year Book No. 3, p. 80; Year Book No. 4, pp. 221–223, and Year Book No. 5, pp. 175, 176.) $7,500.

Systematic observations on the steel tapes suspended in the Washington Monument, for a determination of the after-effect curves, were continued until the middle of March. In the two months following, a great number of observations were made on elastic fore-strain and on the variation of temperature and electric conductivity with strain. A simple method of recording the amplitudes of the longitudinal vibrations of the tape when suddenly loaded was devised and successfully applied. Although the accuracy by this method of measurement is not comparable with that of the cathetometer, the data are, nevertheless, of great value in a study of instantaneous strain. The periods of the longitudinal vibrations of the strained tape for various loads were accurately determined from the records of a chronograph. The final reduction and discussion of all of the data obtained at the Washington Monument is now in progress.

The electric furnace and measuring apparatus mentioned in the last report have been completed and a few observations have been made on the variation of Young's modulus with temperature, due account being taken of the after-effect. It was intended to begin systematic observations with this apparatus when the work at the Washington Monument was completed. There has been some delay on account of the removal of the laboratory equipment from the U. S. Geological Survey building to the Geophysical Laboratory of the Carnegie Institution of Washington. The new conditions, however, are much more favorable for the prosecution of this investigation, and it will probably be possible to obtain a series of observations extending over a long interval of time, on specimens maintained at a nearly constant temperature and practically free from vibrations.

Bibliography of Geophysics.—See under Bibliography, pages 46-54.

HISTORY.

Ferguson, W. S., University of California, Berkeley, California. Grant No. 338. *A History of Athens from Demosthenes to Plutarch.* (For previous report see Year Book No. 5, p. 202.) $1,200.

This work has been continued in various European libraries during the winter of 1906–7, and in the library of Harvard University during the following spring and summer. The results of four special investigations conducted in its interest have been printed in Classical Philology and in Klio, Beiträge zur alten Geschichte, while two additional articles are in preparation and the preliminary study referred to in last year's report has been revised and reprinted. The manuscript of the work proper lacks of completion only the introductory chapter. It will be ready for the press at the end of the year and will make a volume of approximately 400 pages.

Haskins, Charles H., Harvard University, Cambridge, Massachusetts. Grant No. 416. *Study of the documentary materials for Anglo-Norman history.* (For previous reports see Year Book No. 4, p. 238, and Year Book No. 5, p. 202.) $1,000.

The exploration of archives in Normandy and Paris was continued by Professor Haskins during the past summer, and some portions of the work will be carried on by searchers and copyists in the course of the winter. The search for documents in France can be completed in another summer, but it is too soon to say how much time will be needed for the further work of copying, collating, and critically sifting the materials which will be necessary for the proposed calendar of the charters of Norman sovereigns from 1035 to 1154. The English Historical Review for October, 1907, contains a paper on "Knight service in Normandy in the eleventh century" which embodies the results of investigations regarding early Norman military institutions; and an edition of the "Consuetudines et iusticia quas habuit rex Willelmus in Normannia" and a series of documents upon Norman administration in the twelfth century are nearly ready for publication. One or two other special studies are likely to take shape in the course of the present year.

LITERATURE.

Sommer, H. Oskar, "Astolat," Camberley, Surrey, England. Grant No. 417. *Preparation of results of researches on Arthurian romances.* (For previous report see Year Book No. 5, p. 203.) $2,000.

Dr. Sommer reports the completion of work as follows:

The transcript of manuscript Add. 10293, ff. 1-129[a], forming the third volume of "The Vulgate Version of the Arthurian Romances," collated with the original manuscript and with four other manuscripts at the British Museum, containing the same part.

Studying the false Guenever episode in the second part of the Lancelot, and preparing a text of it from the manuscript in the possession of Mr. Henry Yates Thompson, London, and two manuscripts in the Bibliothèque Nationale, Paris, to form an appendix to volume 4 of "The Vulgate Version."

The examination of the section corresponding to the first three volumes in all the manuscripts of the Bibliothèque Nationale; Bibliothèque de l'Arsénal, Paris; Bibliothèque du Roi, Bruxelles; the Philips collection, Cheltenham; the manuscript in the Rhylands library, Manchester, and that of Mr. Henry Yates Thompson, London, and in the British Museum.

Contributions to Romania and Modern Philology have been published, which bring the writer's studies of the last eleven years to a successful conclusion, recalling and reconstructing the trilogy, a cycle embodying the principal branches of the Arthurian romances, the various parts of which exist in the libraries of Lisbon, Paris, Madrid, London, Edinburgh, Venice, and Vienna. With the help of the knowledge of the manuscripts in Paris and London, Dr. Sommer has been able to offer a natural and plausible explanation of the many difficulties previously unsolved.

During a visit to Vienna for the purpose of examining the Portuguese manuscripts, it was possible to make an examination of the three Tristan manuscripts in the Imperial Library.

MATHEMATICS.

Lehmer, D. N., Berkeley, California. Grant No. 374. *Comparison of factor table of first ten millions with manuscript table of Kulik.* (For previous reports see Year Book No. 3, p. 121, and Year Book No. 5, p. 203.) $400.

A careful comparison, entry for entry, has been made with the tables of Burckhardt for the first three millions; with the tables of Glaisher for the fourth, fifth, and sixth millions; with the tables of Dase for the seventh, eighth, and ninth millions, and with the manuscript tables of Kulik for the tenth. Many errors hitherto undetected have been found in all the tables. A complete recount of primes has been made for all the millions. The results of the computations of Meissel and others have been completely verified by actual count. The results of Bertelsen for the successive groups of ten thousand in the tenth million have also been found to agree with actual count.

METEOROLOGY.

Bjerknes, V., and **Sandström, J. W.**, Christiania, Norway. Grant No. 428. *Preparation of a work on the application of the methods of hydrodynamics and thermodynamics to practical meteorology and hydrography.* (For previous report see Year Book No. 5, p. 212.) $1,200.

The first part of a "Treatise on Dynamical Meteorology and Hydrography," dealing with the statics of the atmosphere and the sea, is in press. For the next part, meteorological and hydrographical observations have been made and systematized. This part will treat the kinematics of the atmosphere and the sea, and give practical applications of the equation of continuity for the investigations of air and sea motions.

NUTRITION.

Chittenden, Russell H., Sheffield Scientific School, New Haven, Connecticut. Grant No. 348. *Minimal proteid requirements of high-proteid animals.* (For previous reports see Year Book No. 3, p. 131; Year Book No. 4, p. 259, and Year Book No. 5, p. 213.) Grant No. 376. *The influence of hydrazin upon intermediary metabolism.* $2,500.

Grant No. 348 ($1,500).—This investigation, carried out in the Laboratory of Physiological Chemistry of the Sheffield Scientific School of Yale University, is now completed, and a detailed report of the results obtained is in preparation. A careful study has been made of the influence of different forms of nitrogen-containing food upon dogs as a type of high-proteid animals. The results with many animals show that the standards set years ago by Immanuel Munk and Rosenheim of Berlin, and Jägerroos of Finland, are unnecessarily high. Further, that the deleterious results of a low-pro-

teid diet as found by these investigators were not due to the small amounts of proteid diet taken, but to other causes, since the present investigation has shown that it is quite possible to keep dogs in a condition of physiological and body equilibrium, with maintenance of health, strength, and vigor, on quantities of proteid food and with amounts of non-nitrogenous foods which, according to the statements of the preceding investigators, were insufficient to sustain life. Many interesting results have been obtained, which will be published later.

Grant No. 376 ($1,000).—Attention has been given to the distribution of the nitrogen and sulphur excreted in the urine of dogs poisoned with hydrazin, for the purpose of determining some of the processes which may take place in deranged metabolism, with the hope of thereby offering an explanation of certain phases of intermediary metabolism. The results indicate that in the distribution of the urinary nitrogen very little change occurs, but that the neutral sulphur excreted in the urine is increased—in some cases cystin appearing in the urine. Allantoin excretion is not increased by hydrazin, contrary to previous observers, and its appearance in the urine may be explained as a phenomenon induced by starvation, a necessary condition for such experimental animals. Oxalic acid is largely increased. From histological examination of the various organs, it is concluded that hydrazin acts upon the liver specifically, producing in that organ changes in many respects similar to those provoked by phosphorus. This investigation was carried out in the Sheffield Laboratory of Physiological Chemistry by Professor Frank P. Underhill and Mr. Israel S. Kleiner.

Mendel, Lafayette B., Sheffield Scientific School of Yale University, New Haven, Connecticut. Grant No. 265. *Study of the physiology of growth, especially in its chemical processes.* (For previous reports see Year Book No. 4, pp. 259, 260, and Year Book No. 5, p. 213.) $2,000.

A series of papers on chemical studies of growth is in press and in preparation. Those which have appeared are:

(1) **The Inverting Enzymes of the Alimentary Tract, especially in the Embryo.**
(2) **The Enzymes Involved in Purine Metabolism in the Embryo.**
(3) The Occurrence of Glycogen in the Embryo Pig.

The following papers in the series have been prepared:

(4) The Transformation of Glycogen by the Enzymes of Embryonic Tissues. By Lafayette B. Mendel and Tadasu Saiki. (In press November, 1907.)
(5) The Autolysis of Embryonic Tissues. By Lafayette B. Mendel and Charles S. Leavenworth. (In press November, 1907.)
(6) Changes in the Purine-, Pentose-, and Cholesterol-content of Developing Eggs. By Lafayette B. Mendel and Charles S. Leavenworth. (In press November, 1907.)

The completed researches awaiting publication include investigations on the catalase and lipase of embryonic tissues; the muscular tissue in embryonic life; the lipoids of embryonic organs; in addition to studies mentioned in an earlier report.

Osborne, Thomas B., Connecticut Agricultural Experiment Station, New Haven, Connecticut. Grants Nos. 349 and 439. *For work on vegetable proteids.* (For previous reports see Year Book No. 3, p. 111; Year Book No. 4, pp. 260–262, and Year Book No. 5, pp. 214–219.) $10,000.

Grant No. 349 ($5,000).—During the past year the work which was described in the Year Book for 1906 as begun has been continued. Much of this has already been completed and the results published or in press. The accumulation of large quantities of pure preparations of a large number of different proteins and the experience with complicated methods of analysis have made possible much more rapid progress with these investigations.

The results of hydrolyses of the wheat proteins which were last year reported to be in press have been published in the American Journal of Physiology, volume XVII, pages 223 and 231 (1906).

A full report on the proteins of the wheat kernel has been prepared, in which the work done in this laboratory during several years past has been brought together with that done under previous grants, and made a connected whole. This report has appeared as Publication No. 84 of the Carnegie Institution of Washington. In addition, a new decomposition product of wheat gliadin has been discovered and found to be a dipeptide of proline and phenylalanine. The properties of this interesting and important substance have been described as follows in the American Journal of Physiology, volume XVIII, page 123 (1906):

The new substance crystallized directly from the moderately concentrated solution of the decomposition products which resulted from boiling gliadin with 25 per cent sulphuric acid for 10 hours. On concentration this substance crystallized, mixed with varying amounts of tyrosine and leucine, from which it was separated by precipitation with phosphotungstic acid. This precipitation was repeated until the separation was complete.

The free acid thus obtained is very difficultly soluble in cold water, much more soluble in water at 100°, and crystallizes from this solvent in long, flat prisms, sometimes perfectly rectangular, more often with modified ends. When filtered dry by suction, the crystals exhibit a beautiful mother-of-pearl luster much resembling valine. Dried in the air, the substance contains a molecule of water of crystallization, which it, for the most part, loses in vacuo over sulphuric acid, completely at 120°. Analysis gave the following results:

Water: Calculated for $C_{14}H_{18}O_3N_2 \cdot H_2O$ ..... 6.43 per cent.
Found ..... 6.55 per cent.

Dried at 125°.

	Calculated for $C_{14}H_{18}O_3N_2$.	Found.
	Per cent.	*Per cent.*
Carbon	64.12	63.98
Hydrogen	6.87	6.96
Nitrogen	10.69	10.79

The substance, on rapid heating, decomposes at about 249° (uncorr.), with evolution of gas, to a red oil. It forms a copper salt which crystallizes in well-developed crystals belonging to the orthorhombic system, which on prolonged exposure to dry air, lose water and disintegrate to a green powder. As a consequence the water determinations were found somewhat below that calculated for 3.5 molecules.

Water: Calculated for $C_{14}H_{18}O_8N_2Cu \cdot 3.5\,H_2O$..... 16.30 per cent.
Found ..... 15.74 per cent.

The composition of the water-free copper salt was found as follows:

	Calculated for $C_{14}H_{16}O_3N_2Cu$.	Found.
	Per cent.	*Per cent.*
Carbon.....	51.92	51.88
Hydrogen.....	4.94	5.15
Copper.....	19.65	19.53

The crystals of this copper salt were measured for us by Prof. W. E. Ford, of Yale University, who found that they belong to the orthorhombic system and show the simple combinations of prism, *m* (100), macro-dome, *d* (101), and macro-pinacoid, *a* (100).

The following angles were measured, those marked with an asterisk being used as the fundamental angles from which the axial ratio was calculated:

$m \wedge m''' = 62°.31'*$ $\quad d \wedge d = 64°.44'*$ $\quad m \wedge d = 62°.52'$ (calc. $= 62°\,46'$)

$a : b : c = 0.6071 ; \ 1.00 ; \ 0.3848$

Under the microscope with crossed nicols the crystals showed parallel extinction, confirming the crystallographic evidence of their orthorhombic character. The free dipeptide is readily soluble in dilute acids and alkalies, and gives the xanthoprotein reaction and pyrrol-test with a spruce splinter. The substance is lævo-rotatory in 20 per cent hydrochloric acid. Two observations gave—

$$(\alpha)\frac{20°}{D} = -40.93° \text{ and } -41.55°$$

When hydrolyzed by heating its solution in 20 per cent hydrochloric acid in a sealed tube for six hours at 118° to 125° it yielded 67 per cent of the calculated quantity of pure phenylalanine and 107 per cent of nearly pure proline.

Proteins have been hydrolyzed with the results given in the table on p. 204. For the details of methods of preparation of the proteins, the identification of the products of hydrolysis and the methods of their separation, which were conducted according to the well-known methods developed by Emil Fischer and his colleagues, the publications listed in the bibliography in this volume (pp. 46-54) may be consulted.

An inspection of the table shows that a marked relation exists between the botanical origin of the several proteins and the proportion of the different decomposition products which they yield under the conditions of the analyses. This relation is most marked in the case of the alcohol-soluble proteins of the

	Alcohol-soluble proteins.				Proteins from legumes.		
	Gliadin (wheat).	Gliadin (rye).	Hordein (barley).	Zein (maize).	Phaseolin (kidney bean).	Legumin (pea).	Glycinin (soy bean).
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Glycocoll	0.02	0.13	0.00	0.00	0.53	0.38	0.97
Alanine	2.00	1.33	0.43	2.23	1.80	2.08	(*a*)
Amino-valerianic acid	0.21	(*b*)	0.13	0.29	1.04	(*a*)	0.68
Leucine	5.61	6.30	5.67	18.60	9.65	8.00	8.45
α-proline	7.06	9.82	13.73	6.53	2.77	3.22	3.78
Phenylalanine	2.35	2.70	5.03	4.87	3.25	3.75	3.86
Aspartic acid	0.58	0.25	(*a*)	1.41	5.24	5.30	3.89
Glutaminic acid	37.33	33.81	36.35	18.28	14.54	13.80	19.46
Serine	0.13	0.06	(*a*)	0.57	0.38	0.53	(*a*)
Tyrosine	1.20	1.19	1.67	3.55	2.18	1.55	1.86
Cystine	0.45	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Lysine	0.00	0.00	0.00	0.00	3.92	4.29	2.71
Histidine	0.61	0.39	1.28	0.43	1.97	2.42	1.39
Arginine	3.16	2.22	2.16	1.16	4.89	10.12	5.12
Ammonia	5.11	5.11	4.87	3.61	2.06	1.99	2.56
Tryptophane	(*c*)	(*c*)	(*c*)	0.00	(*c*)	(*c*)	(*c*)
Total	65.83	64.25	71.32	61.53	54.27	57.43	54.73

	Proteins of oil-seeds.			Alkali-soluble proteins from cereals.		Embryo protein.
	Excelsin (para-nut).	Globulin (squash seed).	Amandin (almond).	Glutenin (wheat).	Alkali-soluble protein (maize).	Leucosin (wheat).
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Glycocoll	0.60	0.57	0.51	0.89	0.25	0.94
Alanine	2.33	1.92	1.40	4.65	(*d*)	4.45
Amino-valerianic acid	1.51	0.26	0.16	0.24	(*d*)	0.18
Leucine	8.70	7.32	4.45	5.95	6.22	11.34
α-proline	3.65	2.82	2.44	4.23	4.99	3.18
Phenylalanine	3.55	3.32	2.53	1.97	1.74	3.83
Aspartic acid	3.85	3.30	5.42	0.91	0.63	3.35
Glutaminic acid	12.94	12.35	23.14	23.42	12.72	6.73
Serine	(*d*)	(*a*)	(*a*)	0.74	(*a*)	(*a*)
Tyrosine	3.03	3.07	1.12	4.25	3.78	3.34
Cystine	(*d*)	0.23	(*a*)	0.02	(*a*)	(*a*)
Lysine	1.64	1.99	0.70	1.92	2.93	2.75
Histidine	1.47	2.63	1.58	1.76	3.00	2.83
Arginine	16.02	14.44	11.85	4.72	7.06	5.94
Ammonia	1.80	1.55	3.70	4.01	2.12	1.41
Tryptophane	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)
Total	61.09	55.77	59.00	59.66	45.44	50.32

a. Not isolated. *b*. Not determined. *c*. Present. *d*. Not found.

cereals. A relatively large part of the protein matter of these seeds is readily soluble in alcohol of 70 to 80 per cent, by volume, while zein can be dissolved in all proportions by strong commercial alcohol of 92 to 94 per cent. Proteins of similar solubility have as yet been found in no other tissues of either vegetable or animal origin. All these proteins differ from other proteins thus far studied in yielding no lysine. All of them yield relatively

much ammonia and glutaminic acid, although zein does not yield as much of the latter as some of the other proteins which are not soluble in alcohol.

Another marked feature of these proteins is the very small amount of arginine which they yield, which, in conjunction with the total absence of lysine and the relatively small amount of histidine, makes the total amount of these basic decomposition products extremely small in comparison with the other proteins. The two proteins that appear most alike in this table are those that are extracted by alcohol from rye and wheat flour. These are the two seeds most nearly related botanically. The agreement between these analyses is so close that in view of the character of the methods available for the determinations, there is no ground for assuming that any differences exist between these preparations. This is not the case for any two of the other proteins thus far examined, for each is differentiated in one or more ways from the others. It seems probable that this difference in the constitution of the food of the developing embryo of different seeds has a close connection with the differences of the several species. Unfortunately, it does not seem possible to isolate the part of the protein of rye and barley which is insoluble in alcohol so that these may be compared with the corresponding proteins of wheat and maize. As the table shows, this part of the protein of the two latter seeds yields those decomposition products in notable quantity which are lacking in the part soluble in alcohol. The glutenin of wheat yields much less glutaminic acid than the gliadin and also less ammonia and more bases, but the amount of the two former is large and of the latter small in comparison with the other proteins, so that the constitution of the total protein matter, as a whole, in this important food product differs widely from that of all the other food products thus far studied.

The proteins of the legumes in the table present no very marked feature, for the proportion of the several decomposition products is more uniform than that shown by most of the other proteins. Sufficient differences, however, exist between the three proteins analyzed to justify the conclusion, already reached on other grounds, that these are distinctly different proteins.

Grant No. 439 ($5,000).—Work under this grant is being continued along the same lines as under the previous grant, and it is expected that similar analyses of the few remaining vegetable proteins will soon be completed. The material for these analyses is ready for hydrolysis and the analyses will be completed as soon as possible. Similar analyses will be made of some of the more important animal food proteins, in order that a better comparison can be made between the vegetable and animal food proteins than is now possible. It is expected that substantial progress will be made with this work during the present year.

PALEONTOLOGY.

Wieland, G. R., Yale University, New Haven, Connecticut. Grant No. 434. *Taxonomic (and structural) study of American fossil cycads.* (For previous reports see Year Book No. 2, p. xxxvii; Year Book No. 3, p. 123, and Year Book No. 4, p. 241.) $2,000.

Dr. Wieland reports that the cycad investigations of the present year have been mainly preliminary to the taxonomic and stratigraphic study of the fossil forms from American horizons, and most of the time has been occupied in the quite indispensable study of the European collections of fossil plants in which the cycads are best represented. Amongst the more important collections studied may be mentioned those of Bologna, Stockholm, London and Cambridge, and Paris. A visit to St. Petersburg and Moscow yielded mainly negative results, chiefly because the active study of fossil plants is only now being begun in Russia.

The examination of the famous cycadeoidean trunk of the Zwinger Museum at Dresden (*Cycadeoidea reichenbachiana,* found in 1753, but never adequately described) resulted in the important discovery that this great trunk bears amongst other fruits one large lateral flower-bud with a staminate disk of 16 microsporophylls silicified in marvelous perfection, and of the same general form as the Black Hills cycad disks. Such have not hitherto been found in any European trunks.

The view advanced in Dr. Wieland's monograph on "American Fossil Cycads" (Publication No. 34), that the floral structures of Cycadeoidea show that the evolution of angiospermous flowers has been a reduction process from a megaphyllous ancestry (not very remote from the Cycadeoideæ), has been accepted by many botanists and paleobotanists.

That field, perhaps the most interesting in all the realm of fossil plants, wherein must sooner or later be discovered the direct ancestors of the angiosperms, is therefore at last indicated. Also, in looking forward beyond the present structural and taxonomic studies towards the future development of our subject, it is seen to be especially desirable to reexamine and extend our knowledge of the later Paleozoic and early Mesozoic terranes yielding or likely to yield fossil plants. So, too, the little-known regions of the Far North urgently appeal to us for study, the plant localities of the polar lands already known having yielded such wonderfully suggestive evidence as to ancient origins and distribution.

With these thoughts in mind, a paleontologic reconnaissance in Spitzbergen was attempted last July; but this was rendered unsuccessful of direct result by the abnormal ice floes from Franz Josef's Land, which prevented landing on the west Spitzbergen coast. It is wished to explore Ellesmere Land at another time; though these are only a few of the localities which suggest themselves for future field work.

PHILOLOGY.

Flügel, Ewald, Stanford University, California. Grants Nos. 329 and 460. *The preparation of a lexicon to the works of Chaucer.* (For previous reports see Year Book No. 3, p. 96; Year Book No. 4, p. 242, and Year Book No. 5, pp. 220, 221.) $11,000.

Dr. Flügel reports that the work of collecting the materials for the Chaucer Dictionary was completed in September, and the editorial work proper was begun. He expects to finish the first part of the Lexicon (completing the letter A) by the end of January, 1908. The individual portions of the work done during the year were as follows:

Mr. Moll finished collecting the vocabulary of "Troylus and Cryseyde"; Mr. Rössger completed the work of collecting the vocabulary of "Boece," mimeographed with the old French text on each slip; Mr. Wolderich finished the vocabulary of "The Legend of Good Women"; Messrs. Bernhoff and Hübschmann finished the "Romance of the Rose," and Mr. Hübschmann finished the "Minor Poems" and the "Doubtful Poems." All these slips were collated and corrected by Dr. Flügel and assorted into a rough alphabet by Messrs. Hübschmann and Lindau.

In the libraries of London, Oxford, and Cambridge Dr. Flügel himself collated all the "Doubtful Poems" and the Ellesmere MS. of the Canterbury Tales, the results being published in Anglia, volume xxx. On the basis of this re-collation he was able to clear up a number of doubtful points in the text, and it is now possible to assign an absolutely correct orthography to the catch-words of the Dictionary.

Prof. E. Einenkel has steadily continued his work on the prepositions and particles. Messrs. Rand, Wood, and Geer have carried on, under Dr. Flügel's supervision, the work of alphabetizing the roughly assorted slips, and Mr. Wood has also been engaged on arranging the rhyme-indexes. The copying of words marked in Froissart has been continued by Dr. H. Ram, of San Francisco.

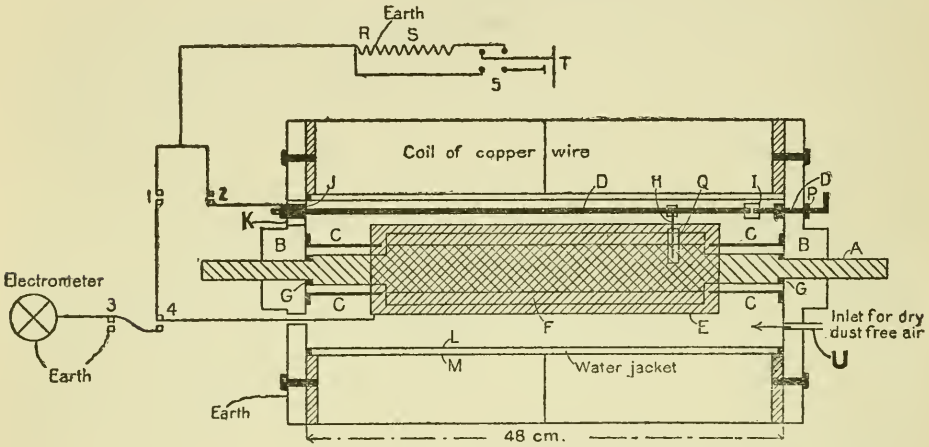
PHYSICS.

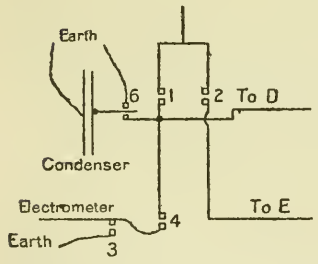
Barnett, S. J., Tulane University of Louisiana, New Orleans, Louisiana. Grant No. 149. *For an investigation of the electric displacement and electric intensities produced in insulators by their motion in a magnetic field.* (For previous reports see Year Book No. 3, p. 124; Year Book No. 4, p. 245, and Year Book No. 5, p. 222.) $250.

To investigate this matter experimentally, the design of apparatus originally proposed to the Institution, and greatly improved later, was abandoned, and the form of experiment described here was substituted. Several important advantages were thus secured, especially the avoidance of all sliding contacts

(except at earthed points) and the greater facility of surrounding the insulated conductors with dry, dust-free air.

An extended series of experiments on sulphur has been completed, a series on rosin has been nearly completed, and experiments on ebonite and paraffin have been begun. In these experiments a bronze cylinder *A* rotates symmetrically within a large cylindrical coil of copper wire wound on a brass bobbin. The bearings *BB*, in which *A* moves, are of lumen, and are screwed to the flanges forming the ends of the brass bobbin. The dielectric under investigation is in the form of a hollow cylinder *F*, cast on the rotor *A*, coaxial with it, and of the same length as its central portion of uniform





diameter. The dielectric cylinder is covered with a thin conducting coat. A little longer than *F*, and surrounding it coaxially is a uniform brass tube *E*. Surrounding this are coaxial brass tubes *L* and *M*, the latter forming part of the bobbin, and both together, with the brass rings soldered between them near the ends, forming a water-jacket. The tube *E* is insulated from *L* by small blocks of amberoid. Between *E* and *L* is a brass rod *DD*, capable of being rotated in the metal bearings *J* and *P* near its ends. The rod is cut near its right end and the two parts are separated by a block of amberoid *I*. At the left end the bearing *J* is insulated by means of a surrounding amberoid block *K*. Screwed to the insulated part of the rod *D* is a brass wire *H*, by which *D* may be brought into electrical connection with the metal coat of *F* without touching the cylinder *E*. For this purpose a small opening *Q* is made in *E*. Small ebonite rings *GG* make the electrical contacts between the rotor *A* and the bearings *BB*, which are earthed, always nearly the same. Brass tubes *CC*, of very nearly the same diameter as that of the

main portion of the rotor A, and coaxial with it, extend from the bearings BB almost into contact with the rotor, and form electric screens. Except for the openings shown in the figure, the space within the water-jacket is closed, with the lumen bearings and brass plates. A slow stream of dry, dust-free air enters this chamber through the inlet U. A resistance box RS, with total resistance $R + S$, always high and constant, and battery T with commutator 5, produce the voltage V_0 (along R) used for calibration purposes. Battery and electrometer connections with J and E are made by amberoid keys, 1, 2, 3, 4, of special design, and an amberoid commutator not shown in diagram.

The dielectric constant K of the insulator F is determined with the connections shown in the lower part of the figure. The condenser is a 0.02 M. F. mica condenser, and key 6 an ordinary Kempe key. Two operations are necessary:

(1) Initially R is given a considerable value, R_1; 1, 2, 3 are closed, H down, 4, 5 open, and the lever of 6 up. Then, in succession, 5 is closed for 30 seconds, H raised, 5 opened, 1 opened, 4 closed, the lever of 6 lowered, 3 opened, H lowered, and the electrometer scale reading taken. The process is repeated with the battery reversed, and the double deflection, d_1, obtained.

(2) Initially R is given a much smaller value, R_2; 1, 2, 3 are closed, 4, 5 open, H down, and the lever of 6 down. Then, in succession, the lever of 6 is moved to "insulate," 5 closed, the lever of 6 moved down and back to "insulate" as quickly as possible, 5 opened, 1 opened, 4 closed, 3 opened, the lever of 6 moved down, and the scale reading taken. The process is repeated with the battery reversed, and the double deflection, d_2, obtained. From d_1, d_2, R_1, R_2, the capacity of the standard condenser, and the dimensions of F, the dielectric constant is readily determined for charging time 30 seconds, its duration in the principal experiment.

The mean magnetic flux ϕ across a section of F perpendicular to its length for a current of 1 ampere in the coil, the corresponding flux ϕ' for a similar section of the thin conductor surrounding F, the mean voltage V from the surface of the bronze cylinder to the earth, for one revolution per second and a current of 1 ampere in the coil, the voltage V_0, the coil current I, and the period of revolution T of the cylinder, are obtained by well-known methods.

The constants of the coil, etc., being determined, an experiment is performed as follows, in two parts:

(1) Calibration: Initially 1, 2, 3 are closed, H down, 4, 5 open. Then, in succession, 5 is closed for 30 seconds, H is raised and 5 opened immediately, 1 is opened 20 seconds or 30 seconds after H is raised (an increase of time producing no effect), 4 is closed, 3 opened, H lowered, and the electrometer scale-reading taken. The process is repeated with the battery reversed. The double deflection d_0, corresponding to the voltage V_0 along R, is obtained.

(2) Experiment proper: Initially, 1 and 5 are open, 2, 3, 4 closed, H down, the rotor at rest, I zero. Then, in succession, H is raised, the motor driving the rotor is started, the coil circuit is closed for 30 seconds, the ammeter is read, 3 is opened, and immediately the coil circuit is broken, the motor is stopped, and the electrometer scale-reading is taken. The process is repeated with the current in the coil reversed. The double deflection d is thus obtained. Speeds are recorded automatically on a chronograph.

For the experiment as now performed, Lorentz's theory, as will be shown in the complete paper, gives the following relation:

$$\frac{d}{d_0} V_0 = \left(\frac{K-1}{K}.\phi + \phi' + V\right)\frac{I}{T} \quad \ldots\ldots\ldots\ldots (1)$$

K being expressed in the $E.S.$ unit, T in the second, and the remaining electrical quantities in the practical units. This equation may also be written

$$\frac{Td}{Id_0} V_0 - (\phi' + V) = \frac{K-1}{K}\phi \quad \ldots\ldots\ldots\ldots\ldots (2)$$

In the case of sulphur, the mean value of the first member of (2) differed from the second member by but a small fraction of 1 per cent, although the separate values obtained for the first term differed much more from their mean. In the case of rosin, V has not yet been determined, a different rotor having been used. The rotors are nearly alike, however, and it is certain that (2) is approximately satisfied by the experiments with rosin. For both sulphur and rosin, $\frac{d}{d_0} V_0$ has been found proportional to $\frac{I}{T}$ as required by (1). This, however, would be expected on any theory. The agreement of the experiments with equation (1) or (2) forms a striking confirmation of Lorentz's theory, according to which the æther remains at rest when matter moves in it, and the matter, electrically constituted, is therefore alone acted upon by the motional electric intensity.

In an investigation on this subject begun much later than this one, but completed in 1904, Dr. H. A. Wilson,* of Trinity College, Cambridge, with the assistance of Professor Larmor, produced a formula for his experiment which is incomplete and incorrect. The correct formula is, suitable units being used,

$$q_0 \frac{d}{d_0} = \left\{(K-1) S_0 \phi + S(\phi' + V + V') + S' V'\right\}\frac{I}{T} \quad \ldots\ldots\ldots\ldots (3)$$

Here ϕ, ϕ', V, I, T, and K have the same meanings as in equation (1); S_0 is the capacity the ebonite cylinder used by Wilson would have if the ebonite were replaced by æther, its electric field confined to the region between the coats, and the lines of intensity all straight and radial; S is the

* H. A. Wilson, Roy. Soc. Phil. Trans., Series A, 1904.

actual capacity of the ebonite cylinder, so far as this depends on the tubes of displacement stretching between the outer coat and the inner cylinder; S' is the capacity of the tubes stretching betwen the outer coat and the case, but does not include the capacity S'' of the tubes stretching between the brushes, connecting wires, electrometer quadrants, condenser plate, etc., and the earth, the coat of the ebonite being the only one of these conductors in motion; V' is the mean voltage from the insulated electrometer quadrants to the outer surface of the outer coat of the ebonite in motion in the magnetic field; d_0 is the electrometer deflection when the outer coat (at rest) and connections have the total change q_0; and d is the electrometer deflection produced when the ebonite rotates in the magnetic field. Instead of S_0, Wilson has what he considered the actual capacity the condenser would have with air substituted for ebonite, so far as lines of displacement stretching between the outer coat and the inner coat are concerned; for S' he has $S' + S''$. Neither one of these quantities was determined. It is therefore impossible to say what difference exists between Wilson's results and those called for by Lorentz's theory. Attention has already been called to another error in Wilson's theory, which, however, while it made the statement of one of his conclusions and of Lorentz's theory incorrect, did not affect his calculations.*

A difficulty which Wilson apparently considered one of the greatest he met in the experimental work, he judged to arise from the abrasion of metal at the insulated brush. This and with it the troublesome terms S' and V', in formula (3) can both be eliminated by surrounding the rotating cylinder and insulated brush with a second cylinder, also connected with the electrometer.

It is expected that this investigation will be completed and ready for publication in the early winter. All serious difficulties appear now to have been overcome.

Burgess, Charles F., University of Wisconsin, Madison, Wisconsin. Grant No. 430. *Investigation of the properties of electrolytic iron and alloys made from it.* (For previous reports see Year Book No. 4, pp. 247–249, and Year Book No. 5, pp. 224, 225.) $2,500.

This work has been carried on in the Applied Electrochemistry Laboratories of the University of Wisconsin and has progressed with practically no interruptions during the past year. Until June 1, 1907, Dr. Oliver P. Watts devoted a portion of his time to the investigation, and he was assisted during the past year by Mr. O. L. Kowalke, who, from June 1 to the present time, has had charge of the work. Various assistants have been employed from time to time, such assistants having been chosen from among the advanced students.

* S. J. Barnett, Royal Soc. Proceedings. Series A, 1905.

The five tanks for electrolytic refining of iron have been in practically continuous operation since submitting the report a year ago, and about 430 pounds of single-refined iron have been produced. On May 2 five additional and larger tanks were added, and these have been run continually, employing special precaution for the production of pure product and using electrolytic iron for the anodes. In this manner a double-refined iron is being produced, and up to the present time over 300 pounds have been obtained. The iron thus produced has been used in most part for the production of alloys in electric furnaces, which have previously been described.

Judging from the numerous inquiries which have come to me, it appears that electrolytic iron has commercial possibilities, although it is not known to be in any way a commercial product at present. The principal prospective commercial use appears to be as a substitute for the high-grade Swedish iron, used for the manufacture of iron alloys, tool steels, and the like. In the investigation no extensive study has been given to the cheap production of the material, and a line of work which it is proposed to take up is to determine how good a grade of iron can be produced from the cheapest form of the impure iron and steel on the market. Thus far high-grade iron has been used as the anodes for the refining tanks.

Some interesting results have been observed in the study of the slimes or residues left in the refining tanks, though this investigation is not complete.

As shown in previous reports, much trouble has been experienced and many losses of charges have occurred in the operation of electric furnaces for the production of alloys. Marked improvements have been made, however, in the method of making magnesia crucibles, and a somewhat extensive study has been taken up concerning the properties of magnesia.

The behavior of magnesia at high temperatures has been studied by Dr. Watts, and among the interesting facts pointed out by him is the apparent reduction of magnesia by carbon at temperatures below 2,000°. This was discussed at length in a paper by Dr. Watts, "The Action of Carbon on Magnesia at High Temperatures," read at a meeting of the American Electrochemical Society, in May, 1907.

Thirty-one electric-furnace runs have been made during the year; 11 of these for making crucibles and 20 for the production of iron-alloy ingots; 313 charges have been weighed out; 294 satisfactory ingots have been produced on the first melt; 12 ingots required remelting, and only 7 were lost by the failure of linings or otherwise. This is a marked improvement over previous practice, when nearly half of the charges were lost. The ingots thus produced were forged, and 262 satisfactory forged bars resulted. From these bars test specimens have been machined, and tests for mechanical, magnetic, and electrical properties have been and are now being made.

Having found the methods for making ingots without losses, the object sought was to prepare various series of iron alloys as free as possible from

carbon, it being the desire to investigate alloys having a lower content of carbon than those with which other investigators have worked. A large number of alloys of iron-copper, iron-nickel, and iron-tungsten have been made, as well as a number of samples of each of the following combinations: Iron-chromium-silicon, iron-chromium-nickel, iron-molybdenum, iron-molybdenum-vanadium, iron-chromium, iron-tungsten-vanadium.

A number of interesting observations have been made in the testing of these alloys, but reports will not be made until the chemical analyses can be secured. In most cases the composition of the alloys is known only by knowing the proportions of materials put into the charge, and, while some checked analyses have been made, a large amount of analytical work is now necessary before the composition of the alloys can be definitely stated, and, when this work is completed, a large amount of material will undoubtedly be available for publication.

Messrs. Bechlem and Wadsworth have conducted a thesis investigation upon high-speed tool-steels made from our electrolytic iron, and they have demonstrated the suitability of the material for this purpose. Prof. A. H. Taylor and Mr. E. M. Terry, of the Physics Department, are conducting extensive tests on the magnetic properties of the electrolytic iron and alloys, and their work is to be continued through this year.

It is the plan to complete during the coming year some of the various lines of study mentioned and to study somewhat exhaustively one or more of the alloys above named.

Carhart, Henry S., University of Michigan, Ann Arbor, Michigan. Grant No. 151. *Determination of the electromotive force of Clark and Weston cells, and of the electrochemical equivalent of silver.* (For previous reports see Year Book No. 3, pp. 124-126; Year Book No. 4, p. 250, and Year Book No. 5, pp. 226, 227.) $500.

The work with the absolute electrodynamometer for the measurement of the electromotive force of the Weston cell has been carried forward during the past year, but no results are to be reported different from those of the preceding year.

Progress has been made in another direction, namely, in the investigation of the silver coulometer, and in the redetermination of the electrochemical equivalent of silver. Preliminary work in this subject was in progress for a year before any attempt was made to determine the silver equivalent. It involved the very important effort to find if possible a salt of silver superior to the nitrate as an electrolyte. This inquiry was stimulated by the theory of Prof. T. W. Richards, which has been widely accepted, that with silver nitrate as the electrolyte a heavy anodic liquid is formed, which increases the deposit of silver if it is allowed to reach the cathode.

Silver perchlorate appears not to have been made the subject of an electrolytic investigation, though it is a very stable salt, before it was taken up under this grant from the Carnegie Institution. Numerous depositions of silver have been made with two coulometers in series, usually one with a nitrate solution and the other with a solution of the perchlorate of silver. Silver perchlorate is not an article of commerce, and it had therefore to be prepared. (For the method, see Trans. Amer. Electrochemical Soc., vol. IX, p. 375, 1906.)

Two conclusions may be drawn from these comparison experiments. First, no evidence has been found confirming Professor Richards' theory. The results are the same whether the anode is contained in a porous cup, or is surrounded, without touching, by a hard quality of filter paper. Second, the perchlorate gives results slightly more uniform than the nitrate, and the silver deposited from the former adheres more firmly than that from the latter. Hence the liability of loss in washing is less with the perchlorate than with the nitrate.

Three determinations of the electrochemical equivalent of silver have been made in terms of the electromotive force of the Weston cell. The current was measured by comparing the fall of potential over two standard ohms in series with the electromotive force of a Weston cell by means of a Wolff's potentiometer. The deposition of silver continued in each case for one hour, and a balance was taken about every minute. When the fall of potential was plotted as ordinates and the times as abscissas, the result was a very satisfactory smooth curve. This curve gave the number of coulombs for comparison with the weight of silver deposited in each cup, one containing a solution of silver nitrate and the other a solution of silver perchlorate.

The following are the results on the basis of 1.01867 volts at 20° C. for the Weston cell set up with mercurous sulphate prepared by precipitation, as reported a year ago (Year Book No. 5, 1906, p. 227):

Experiment.	Coulombs.	Weight of silver deposited.		Electrochemical equivalent.	
		From $AgNO_3$.	From $AgClO_4$.	$AgNO_3$.	$AgClO_4$.
1	2641.58	2.95439	2.95301	0.00111184	0.00111179
2	2647.48	2.95940	2.96020	0.00111178	0.00111181
3	2632.34	2.94442	2.94387	0.00111185	0.00111183
Means				0.00111182	0.00111181

The mean values represent the electrochemical equivalent of silver in grams per coulomb, obtained by means of the absolute electrodynamometer through a Weston cell.

The major part of this work has been ably carried out by my associate, Dr. W. D. Henderson.

Howe, Henry M., Columbia University, New York, N. Y. Grant No. 427.
To determine the influence of ingot-size on the degree of enrichment of the segregate in steel ingots, and the homogeneousness of the ingots outside the region of maximum enrichment. $1,000.

The solidification of every liquid or molten body is a process of differentiation by selection, perfectly pure, simple substances, like distilled water, being excepted. Each layer of the mass in solidifying splits up into two unlike sublayers, one which freezes and thus joins the already frozen part, and one which, remaining liquid, is rejected by the freezing part. In general, the sublayer which remains molten is more fusible than that which freezes and therefore contains an undue proportion of one or more substances which increase the fusibility, *i. e.,* lower the melting-point; and the consequence of this successive differentiation, as layer after layer freezes, is that these fusibility-giving substances are gradually concentrated into the last-freezing part, which may thereby be materially enriched in them. This enrichment of the last-freezing parts and impoverishment of the earlier-freezing ones is known as segregation. In the case of ingots of steel, the substances which segregate most are carbon, phosphorus, and sulphur. The segregation of carbon is extremely important, because carbon influences the properties of the metal very greatly, strengthening it at the expense of its ductility. The enriched part or "segregate" of a given steel ingot may be wholly unsuited for the use to which the ingot as a whole is intended, because its high carbon content may make it too brittle. Further, the heterogeneousness of strength and of ductility which the irregularity of carbon content gives may in itself be very harmful.

The segregation of the harmful elements, phosphorus and sulphur, may be very important, because it may make the last-freezing parts prohibitorily rich in these elements.

This investigation is essentially an attempt to digest and analyze the great mass of scattered results, which many investigators of segregation have reached, to see what laws can be based on them and to fill the gaps which they leave. Such an attempt Professor Howe made some 17 years ago,* but there has been none since.

Professor Howe first analyzed the recorded observations of others and then had ingots specially cast, and examined them by analyzing drillings taken systematically. The total number of previous cases, published and unpublished, which were analyzed, was 168, representing about 2,600 chemical analyses, most of which consisted of determinations of several different elements. The ingots made specially for this investigation were 8 cast-iron ones, 2.25 inches square, and 17 steel ones, from 2.25 inches square to 17 inches square. Their total weight was about 22,000 pounds, or 11 short tons.

* The Metallurgy of Steel, 1890, p. 202.

Professor Howe's investigations resulted in the following conclusions:

Though very large ingots, 30 inches or more across, are subject to very serious segregation, yet within the limits of 2.25 inches square and 16 inches square the influence of ingot-size is not constant, so that the degree of segregation was not greater in his large 16-inch square ingots than in his smaller or even much smaller ones. Large size ought directly to increase segregation; that which offsets this direct effect is, he explains, the greater quietness, and especially the consequent greater opportunity for surfusion, to which large size leads, essentially by lessening the convection currents. Quietness, and especially surfusion, oppose segregation by diverting the course of solidification from the concentric or onion-like type to the landlocking type, in which far-outshooting pine-tree crystals form and landlock part of the molten mother metal, thereby impeding that centripetal travel which is the essence of segregation. A practical inference from this theory is that, in order to lessen segregation, the ingots while solidifying should be kept as quiet and cooled as slowly as practicable, so that quiet and surfusion may be favored.

The net effect of the rate of cooling is not constant, even in sign, for like reasons.

The most enriched spot usually lies in the axis of the ingot, at a distance from the top of between 6 and 28 per cent of the ingot's length. The most impoverished part is probably rarely, if ever, axial.

The enrichment in phosphorus and sulphur seems to be parallel with that in carbon, so that the isophoses and isotheis (lines of equal phosphorus and equal sulphur) are parallel with the isocarbs.

On a general average of many cases, the maximum enrichment in phosphorus is about twice, and that in sulphur is about thrice, that in carbon, but in individual cases the ratio of enrichment in any one of these three elements to that in either of the others varies widely. Unusual freedom from sulphur and phosphorus does not appear to restrain the segregation of carbon, but rather to increase it, if anything.

Professor Howe is not yet prepared to report on the degree of enrichment and the degree of homogeneousness in the remainder of the ingot after discarding certain definite percentages of its upper part, nor on how the richness in carbon influences segregation of that element.

Lewis, E. Percival, University of California, Berkeley, California. Grant No. 150. *Photographic investigations of vacuum-tube spectra of gases and vapors.* (For previous reports see Year Book No. 3, p. 128; Year Book No. 4, p. 253, and Year Book No. 5, p. 227.) $500.

The available time of the writer was spent during the past year in securing a number of photographs of the spectra of the haloid compounds of mercury and of the nitrogen oxides, with a view to an extensive study of the ultra-

violet spectra of compounds. This work is now temporarily suspended in order to make such changes in the apparatus that it may be used in the Crocker eclipse expedition of the Lick Observatory, in which the writer has been invited to take part.

Nichols, Edward L., Cornell University, Ithaca, New York. Grant No. 286. *Quantitative study of fluorescence and phosphorescence, especially at low temperatures.* (For previous reports see Year Book No. 4, p. 254, and Year Book No. 5, p. 228.) $1,000.

The work of the past year under this grant falls under three heads as follows:

(1) Effect of red and infra-red rays upon photo-luminescence. Observations have been made upon two different specimens of Sidot blende. Results have been obtained concerning—

(*a*) The effect of the longer rays before the excitation of the screen, *i. e.*, the effect of these rays in destroying the semi-permanent change in Sidot blende that is left behind after the excitation and decay of phosphorescence. This change is evidenced by the fact that the effect of a given excitation will ordinarily be influenced by the intensity and duration of a previous excitation, even after the lapse of several days. Exposure to certain infra-red rays restores the Sidot blende to a standard condition. We have investigated the influence upon this effect of the intensity and duration of exposure to infra-red.

(*b*) The effect of the longer waves during excitation, *i. e.*, the effect upon the fluorescence of Sidot blende. The effect has been measured by means of a spectrophotometer throughout the luminescence spectrum.

(*c*) The effect of the longer waves after excitation, *i. e.*, during the decay of phosphorescence. The modified form of the decay curve has been determined in numerous cases and under various conditions. The character and relative magnitude of the effect in different parts of the luminescence spectrum were also determined.

(*d*) The relative effect of different wave-lengths in the red and infra-red spectrum in accelerating the decay of phosphorescence.

The work falling under the above heads is ready for publication and will appear in the October or November Physical Review (1907).

(2) Fluorescence absorption. The phenomenon known as fluorescence absorption, *i. e.*, the increase in the absorbing power of a substance during phosphorescence, was discovered by Burke in the case of uranium glass, and has been studied in greater detail by us in the case of several other fluorescent substances. All of the results on this subject have been called in question by Carmichel, who fails to detect the phenomenon. We have therefore repeated our experiments with a new spectrophotometer, and by an entirely different method. Our earlier results were entirely confirmed. A

preliminary account of this work was presented to the Physical Society at the December meeting, 1906.

(3) Cathodo-luminescence of Sidot blende. The spectrophotometric study of the luminescence of Sidot blende under the influence of cathode rays has been begun, but this work is barely under way.

PHYSIOLOGY.

Loeb, Leo, University of Pennsylvania, Philadelphia, Pennsylvania. Grant No. 444. *The toxic action of the poison of Heloderma suspectum.* $1,000.

A considerable number of experiments on the venom of *Heloderma* have been carried out in order to determine some of the general properties of the poison and the susceptibility of different species of animals, especially certain conditions of natural immunity and means which permit the increase of the secretion of the venom. Among the facts ascertained so far it may be mentioned that the secretion of venom is increased by injection of pilocarpin in a similar way as other glandular secretions. The fatigue of the gland after repeated injections has been investigated. The immunity of *Heloderma* towards its own poison as well as its susceptibility towards certain snake venoms has been ascertained. It is expected that a full report of the results obtained so far will be published in the near future.

Reichert, Edward T., and **Brown, Amos P.**, University of Pennsylvania, Philadelphia, Pennsylvania. Grant No. 188. *Research on the crystallography of hemoglobins.* (For previous reports see Year Book No. 3, p. 134, and Year Book No. 4, p. 262.) $1,000.

Since receiving the grant of the Carnegie Institution of Washington, in April, 1904, work upon the crystallography of hemoglobins has been actively prosecuted, whenever the weather and the supply of material permitted. Methods of promoting or retarding or otherwise influencing crystallization have been originated or improved. By retarding crystallization, measurable crystals have been produced from bloods, in which, on account of their rapid formation, it has heretofore been impossible to develop them. By methods which promote crystallization it has been found possible to produce crystals from bloods not heretofore crystallized. Through original processes we have, in specimens of certain species, been enabled to crystallize at will one or another of the several forms of oxyhemoglobin present.

Crystals from the bloods of 100 species have been studied. The photographic records of these crystals of oxyhemoglobin, hemoglobin, the "methemoglobins," etc., will be found in over 1,500 negatives that have been prepared, and from these a selection (probably one-fourth) will be made for illustration of a memoir. Crystallographic characters have also been recorded in sketches, records of measurements, and crystallographic notes,

from which line-drawings, to illustrate the text, will be made. Much calculation and study from these notes must be done before the final results of the research can be definitely formulated.

From a preliminary review of these results certain facts stand out very prominently:

(1) The constancy of generic characters in the crystals. For instance, the genera that have been represented by a considerable number of species, as *Felis, Canis, Papio, Equus,* etc., show in each case constancy in the characters of the crystals in each genus, with marked differences both in axial ratios and in crystal systems between the crystals from the different genera. When the characters of the crystals from any one of these genera are tabulated, they at once recall to the mineralogist the crystallographic groups of minerals. The crystals of the genus *Felis* are as strictly isomorphous as those of the calcite group of the rhombohedral carbonates. As an example of the individuality of these generic characters, the following example may be cited: A sample of blood, marked as that of a certain species of baboon, was received from one of our zoological gardens. Upon making preparations and examining the crystals, it was at once evident that they did not correspond to any species of baboon thus far examined, nor did they show the characters of the crystals of this genus. They were identified by their crystallographic characters as belonging to the cats (genus *Felis*), but not to any species thus far examined. Inquiry at the zoological garden from which the blood was received showed that the animal recorded as being subjected to a postmortem examination on the date when the blood was collected was a species of cat (genus *Felis*), but not one of which we had previously examined the blood.

(2) Specificity in the crystals of a genus. The crystals of different species of a genus can usually be distinguished from each other by definite differences of angle, when they are favorable for good measurement, while preserving their isomorphous character as belonging to a definite genus. From the difficulty of measurement in many cases it is hard to give these differences a quantitative value, but the variation in habit of the crystals and their mode of growth will often show specific differences.

(3) The occurrence of several types of crystals of oxyhemoglobin in many species. The oxyhemoglobin of some of them is dimorphous, crystallizing in two systems, or even trimorphous in many cases. Here it is generally seen that the crystals first formed crystallize in a system of a lower grade of symmetry than those formed later. When several types of crystals occur in the species of a genus, they may each be arranged in isomorphous series. The explanation of these observations seems to be indicated by the results obtained.

(4) The constant recurrence of certain angles, either plane or dihedral, in oxyhemoglobin, hemoglobin, and the " methemoglobins" of various species, even when widely separated zoologically and when the crystals belong

to various systems. This indicates a common substance in hemoglobin or a common structure in the various hemoglobin molecules.

(5) The importance of twinning in the formation of crystal aggregates and the constant recurrence of certain types of twinning in all of the hemoglobins. These results will likely throw light upon the mechanism of twinning and be of importance in general crystallography.

(6) Differences between oxyhemoglobin and hemoglobin or reduced hemoglobin, in certain species. Undoubted differences between the crystals of these two substances in the crystals of the same species have been observed.

Apart from the many important lines of investigation suggested by this research, its bearing upon zoological classification alone makes it highly desirable that the investigation be extended to include a large number of species not yet examined.

PSYCHOLOGY.

Franz, Shepherd Ivory, Government Hospital for the Insane, Washington, District of Columbia. Grant No. 80. *For investigation of the functions of the cerebrum, with special reference to the functions of the association areas.* (For previous reports see Year Book No. 4, p. 263, and Year Book No. 5, p. 235.) $1,000.

The work on the frontal lobes noted in the last report as completed has been published as a monograph in the series "Archives of Psychology." The general conclusions of this study were given in the last report (Year Book No. 5, p. 235). An account of inquiries into the functions of the temporal lobes is in preparation.

Porter, James P., Clark College, Worcester, Massachusetts. Grant No. 445. *Variation in the instincts of orb-weaving spiders.* $500.

Dr. Porter reports the successful removal of spiders of the species *Argiope riparia* and *transversa* from Worcester, Massachusetts, to Shawnee-on-Delaware, Pennsylvania. This latter locality was chosen chiefly for the reason that on the large estate of Mr. C. C. Worthington suitable places were kindly offered where the spiders could find their natural habitat and at the same time be carefully protected from disturbances of any sort. Both the above expectations have been very satisfactorily fulfilled. Inasmuch as the work is still in progress, Dr. Porter has had neither the time nor complete data to make possible a quantitative expression of the results. The observations fall naturally into the following outline:

1. Variation in webs:
   - *a.* In the number of attachments to solid objects.
   - *b.* In the number of radii.
   - *c.* In the number of sticky concentrics above the free zone.
   - *d.* In the number of sticky concentrics below the free zone.
   - *e.* In the number of concentrics in the inner zone.

With respect to the above parts of the web, counts have been made of approximately 200 *Argiope riparia*; of about the same number of *Acrosoma spinea;* some 40 *Epeira hortorum;* about 100 of *E. sclopetaria,* and of a smaller number of the triangle spiders, probably *Hyptiotes cavatus, E. trifolium, E. insularis,* and *Argiope transversa.* Work with the last three is still being continued. *Acrosoma spinea* has additional interest for the reason that *a priori* it should be less variable, having fewer accessories. *Epeira hortorum* is interesting from the fact that the web is as nearly in the horizontal plane as the others are in the vertical, and it has a screen beneath.

Since the counts on a single web, when all the five parts are included, may be as many as 125, it is readily seen that not many can be made, as they must be confined to the early part of the day. The webs are usually so torn by the middle of the day that it is unsafe to attempt to count their parts during the afternoon.

2. The ontogenesis of the web is very interesting. The web of the young of *riparia* and *transversa* is very different from that of the adult. This change with age involves chiefly the omission of certain parts.

   a. The zigzag or "winding stair" in webs of young *riparia* is curved about the center of the web to the number, at times, of 5 or 6. These are soon reduced to a single zigzag, and this is fairly constant with *riparia.* With the closely allied species, *Argiope transversa,* there is no zigzag at first. The lower half appears some days before the upper. The entire structure is more often omitted in the web of this species than in that of *riparia.* In the web of *Acrosoma spinea* there is no lower half to the zigzag. The upper half is probably a more constant structure than with *riparia.* This structure is more variable in the webs of *riparia* males than those of the females of the same species. In webs of males of *transversa* it is seldom found.

   b. The side-screens show similar changes with age. The one on the under side of the web appears first and is the more constant. *Transversa* is less variable here, at least, when young. Both screens are often absent, and, with the adult *transversa,* about October 1 they are rarely present. Since the males approach the web of the female by means of the lower screen, their definiteness of approach could be observed in connection with the above. If there is but a single male his approach is a fairly definite one.

   c. The anchor line, or the thread from the center of the web on the side opposite the spider to the upper side-screen or plant, is a most variable structure. There may be at the same time as many as six of these in the same web. It is probably sufficiently constant for short periods to be considered a product of instinct.

On the points *a, b,* and *c* there are many hundreds of observations. All observations possible have been made on those webs having a signal thread

from the center up to the nest; also on those which build an open-sector web, *Zilla atrica* and *Epeira aureola.* Dr. Porter found an *Epeira cavatica* making alternately open and closed webs. It habitually makes a closed web. Other Epeiræ either make open webs or they are soon torn so as to appear as such. *Zilla* as a species makes open-sector webs, but individuals may be found with webs entirely or partly closed. One of two *Epeira aureola,* both followed each day for weeks, built a partly closed web. On pulling the large nest down so that it and the signal thread was farther away from the web (thus artificially bringing about the relations noted in those of the *Zilla* webs which were solid) it was led to make the web less open. We seem to obtain here a clue to the origin of the open-sector web, as well as evidence of very great variation.

Some 34 *Zilla atrica* spiders were brought from Gloucester, Massachusetts, to Shawnee-on-Delaware, Pennsylvania. Some were found to build closed webs. Very hard rains and cool weather interfered with the attempts to follow them as long as had been hoped.

The correlation of variations in the web-making and cocoon-making instincts is the subject of immediate concern. Some 700 cocoons, chiefly *riparia,* have been collected in the last few days. Previous work with these cocoons suggests that there may be important facts in the life history of spiders, at least the *Argiope,* which are not yet known.

The rains coming at about the break of dawn show many webs left unfinished at about the same stage of completion. Spiders building webs in protected places complete them. *Epeira sclopetaria* have been observed to emerge from their nests at about the same time in the evening.

Interesting additions have been made to the observations previously published on the mating of *Argiope.* As many as 10 males may attempt to mate with a single *riparia* female. Specimens are now being prepared for microscopic study to determine whether copulation is structurally impossible until the female molts. From the behavior of the males and the structure visible to the naked eye the writer has deemed it worth while to follow this further. Tests in two cases point to the fact that the successful male dies during the first few minutes of copulation. Unsuccessful males to the number of three or four are killed in their later attempts to copulate with the same female. Later these may be eaten by the female or other males.

In order not to deplete too much the supply of spiders for another year, only a limited number of spiders of *riparia,* both male and female, was collected and preserved during this past season. This will limit for the present the study of variation in size of parts and color markings. It is the intention to carry this much further another season.

ZOOLOGY.

Castle, W. E., and **Mark, E. L.,** Harvard University, Cambridge, Massachusetts. Grant No. 418. *Continuation of experimental studies in heredity.* (For previous reports see Year Book No. 3, p. 136; Year Book No. 4, p. 276, and Year Book No. 5, pp. 243, 244.) $500.

Dr. Castle reports that since the last report was made by him an adequate explanation has been obtained of the curious phenomenon of atavism or reversion, so far as concerns the pigmented coat of guinea-pigs, rabbits, and other rodents. The phenomenon is this: Upon crossing two simple color varieties, such as black and yellow, young are obtained which are identical in appearance with closely related wild rodents, and doubtless also with the actual ancestral species from which the domesticated varieties have descended. The resemblance to a wild ancestor has been supposed to extend, in such cases, to all characters of the species, including temperament, but this is certainly not true in the cases which have come under his observation. If reversion in mental traits occurs as a result of crossing (a thing in itself entirely possible), it is not because of a necessary association of mental traits with any particular type of pigmented coat.

Reversion in mental constitution *might* occur (we have no certain evidence that it ever *has* occurred) along with reversion in coat-pigmentation; but, if so, it would be due to a simultaneous inheritance of factors independent of those which produce the pigmented coat. The explanation obtained for reversion is this: The wild or ancestral type of coat is a composite character, resulting from the simultaneous presence of at least three independent factors, one or another of which was wanting in each parental variety, but all of which were brought together by a combination of the parental varieties. This explanation constitutes an extension merely of the basic Mendelian principle of inheritance, the principle of unit-characters independent of each other in their inheritance.

In two brief communications explanation has been made of the factors which are involved in the reversion in coat-pigmentation in guinea-pigs and in rabbits, respectively. A fuller account is deferred to a later publication.

Whether unit-characters are mutable or immutable in nature remains as yet the central problem for experimental study in the field of heredity. Towards its solution the experiments in progress are mainly directed. They include (1) selection experiments for the modification of color-patterns among spotted rodents, or for the fixation of patterns arbitrarily chosen; (2) experiments in repeated crossing of contrasted types of pigmentation, to see whether modification of those types can thus be brought about; (3) experiments to ascertain what are the physiological differences between those types.

Experiments in hybridizing *Cavia aperea* (the Brazilian cavy) with the guinea-pig have been attended with considerable success. While in previous

years all hybrids reared have been completely sterile, a female hybrid has this year been obtained which is fertile with the wild male. The hybrids show blending inheritance as regards bodily proportions and apparent Mendelian inheritance as regards color characters, but a cross of the hybrid with the guinea-pig is required fully to establish the occurrence of Mendelian segregation.

The polydactylous race of guinea-pigs described in Publication No. 49, which was produced from a single abnormal individual, remains entirely stable.

Three student-assistants have rendered valuable aid in the prosecution of the experiments, viz, W. G. Vinal, E. L. Walker, and W. E. Wing.

On the material side the experiments have been more successful than in any previous year. The number of guinea-pigs reared in this series of experiments now amounts to over 11,000; the number of rabbits to over 1,500, and that of rats to over 4,000. Epidemics occurring in cold weather are still the chief obstacle to the guinea-pig experiments. The crowded condition of our animal-room is undoubtedly in part responsible for this, a difficulty which is soon to be remedied, through the generous cooperation of the Harvard Corporation.

Dr. Mark reports that as material for the study of spermatogenesis and ovogenesis in the hybrids between normal and rumpless fowls has not been secured in sufficient quantities during the year, attention has been given to the two related lines of work referred to in his report a year ago.

(1) In studying spermatogenesis in hybrid guinea-pigs it seemed desirable to make comparisons with cases of abnormal spermatogenesis in non-hybrid animals, due to diseased conditions of the animal. Consequently the work of Mr. Gulick was extended to cover two such cases—one the male of *Cavia cobaya;* the other that of *C. aperea.* In both instances the diseased condition of the animal led to conditions of degeneration in the sexual products, which were in most particulars not to be distinguished from those seen in the apparently healthy hybrids resulting from the crossing of a male *C. aperea* with females of the domestic species (*C. cobaya*). It further appears that there are probably two periods in spermatogenesis at which the evidences of abnormality (degeneration) are more conspicuous than at others, viz, during synapses and mitoses, especially those of the primary spermatocytes. The results of this study are nearly ready for presentation, but the observations ought to be extended to cover a greater number of cases before a final paper is published.

(2) In collaboration with Mr. Manton Copeland, work on spermatogenesis in Hymenoptera has been continued according to the plan mentioned in the last report. The conditions in the mud wasp (*Vespa maculata* Linnæus) have been studied, and a brief account of the results has been published.

Through correspondence with Leonard Doncaster, Esq., of Birmingham University, England, who has been studying spermatogenesis in the honey-bee, and through interchange of drawings, we have been able to convince him of the inaccuracy of his published conclusions as to the number of chromosomes, and he has now published (Anatomischer Anzeiger, Bd. 31, Heft 6, Aug., 1907) a second article, in which he puts himself in agreement with us on this point.

Crampton, Henry E., Columbia University, New York, N. Y. Grant No. 137. *Determination of the laws of variation and inheritance of certain Lepidoptera.* $500. (For previous reports see Year Book No. 2, p. xli; Year Book No. 3, p. 136; Year Book No. 4, p. 276, and Year Book No. 5, pp. 244–245.) Grant No. 431. *The study and collection of gasteropod mollusca of the genus Partula.* $3,000. $3,500.

Grant No. 137.—The acquisition of data relating to the variation, correlation, and inheritance of the characters of different developmental stages of *Philosamia cynthia* was completed by the determination of the dates of emergence of the living individuals reared during the summer of 1906. The statistical treatment of the data is now progressing.

Grant No. 431.—In prosecuting the research upon the variation, distribution, and mutation of snails of the genus *Partula,* a journey to the Society Islands was undertaken during the spring and early summer of 1907, supplementing an exploration of the previous year. The Windward Islands—Tahiti and Moorea—were entirely covered in the course of this year's explorations; 55 valleys of the former island and 20 of the latter furnishing more than 30,000 specimens. Several thousand adolescent snails were also obtained. As the various species of *Partula* are viviparous, and as more than half of the adults contain young, whose characters are often distinctly expressed, it is possible to study the problem of inheritance in its relation to species-differentiation under exceptionally favorable circumstances. The material also makes it possible to give a statistical determination of specific limits. While final conclusions must be withheld until a close study has been made of all the material in hand, certain general statements may be made. As reported by Mayer, the species of *Partula* are often very local in their distribution, like the Achatinellidæ of the Hawaiian Islands. Evidence of mutation has been secured in several cases in Tahiti, and in at least one instance in Moorea. The fixity, parentage, and place of origin of the mutant forms can be established with exactness. The process of specific change is proven to be a continuous one for recent times, some sinistral species being slowly converted into dextral ones.

Duerden, James E., Rhodes University College, Grahamstown, South Africa. Grant No. 432. *Continuation of investigations on the morphology and development of recent and fossil corals and physiology of the Zoantharia.* (For previous reports see Year Book No. 2, p. xli; Year Book No. 3, p. 137; Year Book No. 4, p. 277, and Year Book No. 5, p. 245.) $500.

Owing to the necessity, in Dr. Duerden's new appointment, of conducting certain physiological and genetical researches having some local importance, it has not been possible to devote much time to coral studies, but it is hoped that it may be possible to secure some trained assistant to complete the working over of the material in hand.

Eigenmann, C. H., Indiana University, Bloomington, Indiana. Grant No. 68. *Investigation on the blind fishes in the caves of Cuba.* (For previous reports see Year Book No. 2, p. xlii; Year Book No. 3, p. 138, and Year Book No. 4, p. 278.) $1,000.

Professor Eigenmann reports that as a result of the investigation carried on with the aid of the above grant, it has been found that the Cuban blind fishes give birth to living young about 20 mm. long; that some of the young at the time of birth have eyes that are well formed and can be moved, which probably might be functional; that the eyes in different individuals at the time of birth differ greatly, and that they have scleral cartilages much too large for the eyes; that the eyes of even the youngest individuals examined show signs of degeneration, and that the eyes after birth undergo a rapid degeneration, emphasized first by the loss of the lens and the scleral cartilages; that further degeneration is progressive to old age, where the vanishing-point is reached; that this degeneration may early result either in the shriveling of the eye or in its great distention, and that these two methods may be found on opposite sides of the same fish; that this eye varies to such an extent and is disappearing by a progressive process which excludes mutation and natural selection as possible explanations. The final report has been submitted for publication.

Hodge, Clifton F., Clark University, Worcester, Massachusetts. Grant No. 424. *Studies in the domestication and evolution of varieties of the grouse, partridge, and quails of North America.* $500.

The work of domesticating the ruffed grouse and American quail or bobwhite has progressed well during the season. During May 54 eggs of the ruffed grouse were obtained, of which 39 hatched. Of this number 10 fine, healthy birds have been reared, the largest flock that has ever been reared in domestication. As to the rest, an attempt was made to rear one brood of 16 on clean ground with a hen. All of these sickened and died early in the

season. This line of experiment is now closed, and the result shows why the ruffed grouse has never been domesticated. Of the remaining 23 reared in the brooders, 2 escaped and were lost, 3 died as result of accidents, and one lot of 8 were killed by overheating of a brooder. Invaluable knowledge and experience, however, has been gained; the best headway of any year since beginning the work in 1902 has been made.

With the bob-white results are better and the knowledge of the species gained is of much more practical value. A single pair were kept as household pets. Eighteen eggs were laid in a window cage, of which 11 hatched. The hen was immature, a late chick of the fall before, which probably accounts for the small number of eggs and the large percentage of infertility. In addition to the above, 11 chicks were obtained from an incubator at the State Game Commission's hatchery and 10 eggs from the same source. Again the experiment of rearing one brood of 6 chicks with a hen was tried, and all these sickened and died within the first week. Of the rest there are to date 20 healthy young birds. Microscopical examinations, with bacteriological cultures, have resulted in proving pretty conclusively that a parasitic disease, contracted from the hen, has been the cause of fatalities.

Howard, L. O., U. S. Department of Agriculture, Washington, District of Columbia. Grant No. 250. *Preparation of a monograph on American mosquitoes.* (For previous reports see Year Book No. 2, p. xlii; Year Book No. 3, p. 138; Year Book No. 4, p. 279, and Year Book No. 5, pp. 245, 246.) $3,000.

Dr. Howard reports that very considerable progress has been made toward the completion of the monograph; a large amount of manuscript has been completed, and very many illustrations have been prepared. After the funds appropriated by the Institution were exhausted, it was realized that the geographic field had not been thoroughly covered, and during the present year, as during the year 1906, efforts have been made to complete the collection of material in all stages so as to make the monograph worthy of the Institution and satisfactory to its authors.

Dr. H. G. Dyar and Mr. Frederick Knab undertook at their own expense an expedition to British Columbia to work out the full life-histories of certain species of mosquitoes known to exist there, and, with the assistance of the Isthmian Canal Commission and the consent of the Honorable Secretary of Agriculture, Mr. August Busck was sent to explore thoroughly the mosquito fauna of the Canal Zone. Previous to this expedition only seven species of Culicidæ were known from the Zone, but Mr. Busck returned with more than ninety species, of which thirty were new to science. The previous failure to secure proper material from the latter region was due to the fact

that undue reliance had been placed upon the promises of voluntary observers. As occurs in so many works of similar character, former estimates as to the time of the completion of the monograph must be exceeded, and it now seems probable that it will be impossible to submit manuscript and plates before the spring of 1908.

Mark, E. L., Harvard University, Cambridge, Massachusetts. Grant No. 433. *Study of maturation and early stages in the development of the ova of mice.* (For previous report see Year Book No. 5, p. 246.) $300.

For the study of the ova of mice the stock of individuals has been kept most of the time at between 400 and 500. From these mice during the year about 225 adult females have been carefully observed and killed at appropriate times; likewise some 50 young females varying in age from young embryos to young animals several weeks old. Somewhat more than half this material has been sectioned and studied. The great amount of time required both for the care and observation of the mice and for the histological preparation of the material has made it impossible for Mr. Long to complete a survey of the whole material, even with the help of an assistant to feed the mice and the employment of a student to do some of the sectioning.

The thousand or more eggs which we are now engaged in studying form a pretty complete series extending from a period immediately before the beginning of maturation to that of the formation of the two pronuclei; and yet some of the most important stages are few in number or altogether wanting, so rapidly do certain parts of the maturation take place. We shall concentrate our efforts toward obtaining these rarer stages.

Although there is considerable individual variation, these points have been established:

(1) Ovulation occurs about 15 hours after parturition.

(2) Under favorable circumstances the whole process of maturation may be completed in about 8 hours.

(3) The first maturation spindle is always formed before ovulation.

(4) The first polar cell is formed before or during the rupture of the follicle.

(5) The second maturation spindle is formed immediately after the appearance of the first polar cell, and in most cases persists till a spermatozoön comes in contact with the egg; or, if fertilization does not take place, till the egg degenerates. It follows that, normally, the spindle seen in eggs taken from the oviduct is the second maturation spindle, whether the first polar cell is present or not.

(6) Whether a given spindle is the first or second maturation spindle may be determined by the character of the chromosomes. Those of the first spindle are large and of characteristic shape and structure; they are tetrads.

Those of the second spindle are smaller, more irregular in shape, but often resemble tetrads to such a degree that were it not possible to make a direct comparison with the chromosomes of the first spindle, they might be mistaken for tetrads. This is because each element of a dyad has sometimes the form of a dumb-bell.

(7) The first polar cell disappears. While it is not possible, as yet, to say whether it may not sometimes make its way, actively or passively, through the zona pellucida, the only direct evidence at present indicates that it degenerates while lying between the egg and the zona. We have a series of stages showing a process of degeneration which begins with the disintegration of the chromosomes and ends, before complete disappearance, with a very much flattened, clear, homogeneous body.

Some of the points still to be worked out are:

(1) The precise method of the division of the tetrads, for which there are few specimens.

(2) The precise method of the division of the dyads, for which there are no specimens.

(3) The origin of the tetrads.

(4) The origin and fate of the centrosomes and other polar corpuscles.

Naples Zoological Station, Naples, Italy. Grant No. 419. *For maintenance of two tables.* (For previous reports see Year Book No. 2, p. cliv; Year Book No. 3, p. 145; Year Book No. 4, p. 288, and Year Book No. 5, p. 247.) $1,000.

As in previous years, the grant was made to aid the laboratory in paying for the maintenance of two research-tables. The director of the laboratory assigned the tables during the past year to Mr. Addison Gulick, of Harvard University; Dr. E. L. Rice, of Ohio Wesleyan University, and Mr. Edwin C. Starks, of Stanford University.

Wilson, Edmund B., Columbia University, New York, N. Y. Grant No. 370. *Researches on the chromosomes of insects and other animals with reference to the cytological basis of sex-production and Mendelian inheritance.* (For previous report see Year Book No. 5, p. 250.) $500.

During the past winter great progress has been made with the series of researches on which Dr. Wilson has been engaged. Nearly a thousand microscopical preparations have been made, and over 300 photomicrographs and 100 lantern-slides have been prepared. It is his intention to publish a series of these photographs in the future. A few of the more important results have been published in an article in the Biological Bulletin for April, 1907, others have been announced in two papers read before the American Society of Zoologists and the New York Academy of Sciences, and

still others presented before the meeting of the International Zoological Congress in Boston. Dr. Wilson has in preparation two extended papers based on these results, and others will follow as the material is worked out by himself and his students.

The results thus far obtained are in part entirely new, in part an extension and confirmation of Dr. Wilson's earlier work. While too complex to admit of brief review, a list of some of the results in which he is most interested is appended:

(1) The new phenomenon of the "supernumerary chromosomes" has been brought to light (a paper on this subject is well advanced for publication), which gives new and important data bearing on the theory of the individuality of chromosomes and the origin of the unpaired sex-chromosome.

(2) A new type of chromosome-couplings has been discovered in the Hemiptera, which gives a possible explanation of character correlations in the adult.

(3) Constant chromosomal differences have been found between forms so nearly related that they can not be distinguished otherwise by systematists. This offers a possible explanation of "physiological species."

(4) A mass of new data has been obtained bearing on the problems of synapsis, reduction, sex-production, and Mendelism. A long time, possibly several years, will be required for the full study and analysis of these data.

It is Professor Wilson's intention to go into the field again to procure additional material for study along the above and other lines.

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